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THE GRAND EXPERIMENT AT INYOKERN

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THE GRAND EXPERIMENT
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History of the Naval Weapons Center, China Lake, California

Volume 2

THE GRAND EXPERIMENT AT INYOKERN

*Narrative of the Naval Ordnance Test Station During
the Second World War and the Immediate Postwar Years*

By

J. D. GERRARD-GOUGH

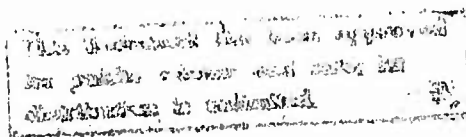
and

ALBERT B. CHRISTMAN

Naval Weapons Center

With an Introduction by
REAR ADMIRAL JOHN D. 'I. KANE, JR., USN (RETIRED)
*Director of Navy History and Curator
for the Navy Department*

Naval History Division
Washington, 1978



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Foreword

The distinguished scholar Dr. Vincent Davis, in reviewing *Sailors, Scientists, and Rockets*, the first volume of this series, stated, "If the first volume is a reliable indicator, all the books in this series will be required reading for everyone with an interest in science and technology, contemporary military history, government-science relationships and related subjects." We believe this second volume meets the same high standards as the first and in its own right provides new insights into the weapon development process.

It is fitting, as has been done in this history, that we examine both past successes, which should help us reaffirm fundamental principles, and past difficulties, which should be avoided in charting future courses. The historical perspective that comes from such examination is essential in understanding the process of weapon development with its many unique interactions between the military and science, headquarters and laboratory, and laboratory and the Fleet.

For these reasons, this Command regards this history series as a useful tool to help the Naval Weapons Center fulfill its essential mission: Developing missile weapon systems and air warfare systems for the Fleet. But this is more than a local history, for the research and development process that evolved at this Center has had its influence on the research and development philosophy of the Navy and most certainly upon the weaponry of the Navy and other armed services of this nation and those of the free world.

In view of the broad application of this history, we of NWC are especially appreciative of the continuing support we have enjoyed from the Director of Naval History, Rear Admiral John D. H. Kane, USN (Ret.), and his predecessors Vice Admiral Edwin B. Hooper, USN (Ret.), and Rear Admiral E. M. Eller, USN (Ret.). With that support we are hopeful that this second volume will enjoy the same

success as the first and will add further dimension to the story of military-scientific cooperation in providing the superior weapons needed by this nation in this era of technological complexities.

R. M. HILLYER
Technical Director
Naval Weapons Center
April 3, 1978

W. L. HARRIS, RADM, USN
Commander
Naval Weapons Center

Introduction

Seven years ago the Naval History Division published the first volume of this series. That book traced the background leading to the establishment of the Naval Ordnance Test Station, China Lake, in November 1943 and discussed the Station's initial months of operation. It assessed the Navy's early work with rocketry and the evolution of naval-scientific relationships before turning to the wartime rocket program undertaken for the government by the California Institute of Technology. The actions of the Navy's Bureau of Ordnance in creating the Naval Ordnance Test Station at China Lake were directly related to the latter project, for at this barren tract in the Mojave Desert, the Navy's initial task was to support the California Institute of Technology in the development of air-launched rockets.

In the present work, Albert B. Christman, the author of the earlier volume, has joined with J. D. Gerrard-Gough to record the history of China Lake from its commissioning in 1943 through the spring of 1948. They recount how, in the last two years of World War II, the rocket program reached its full development as the weapons tested at the Naval Ordnance Test Station were used by American combat forces throughout the world. During the same era, the Navy completed major construction projects to provide the necessary facilities and housing at this remote location. In 1945 the Navy also oversaw the building at China Lake of the Salt Wells Pilot Plant. Here the skills developed by the California Institute of Technology in producing rocket propellants were applied to the manufacture of the nonnuclear explosive charges used in atomic bombs.

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Equally as significant as this wartime record was the fundamental change in the Station's mission during the first three years of the postwar era. From its original status as an activity that supported a wartime contract, China Lake evolved into a command with an exceptionally broad span of capabilities. This change had been foreseen for some time by leaders of the Bureau of Ordnance who realized that the naval establishment needed a permanent center for the development of advanced weapons; they recognized the Station built for the World War II rocket program as the nucleus for such an organization. But, in the midst of the drastic demobilization following the end of hostilities, it is remarkable that their objective was maintained and that the Navy was able to provide the major resources necessary for the further expansion of China Lake.

The problems of implementing this transition were manifold. They ranged from the task of fitting the civilian scientists and technicians—many of them former employees of the California Institute of Technology—into the civil service system, to the challenge of organizing the efforts of naval officers and civilian scientists in pursuing their common goal of developing superior weapons. There also was the task of expanding the range of the command's work. By 1948, in addition to testing rockets, China Lake was involved in the full spectrum of research, development, and pilot production of these weapons, as well as guided missiles, underwater ordnance, and other systems. The Navy additionally assumed from the California Institute of Technology the management of the Salt Wells Pilot Plant that through the postwar years continued to provide components for the nuclear weapons being produced by the Manhattan Project and its successor, the Atomic Energy Commission.

In tracing this record of notable achievement, the authors place their narrative in the context of the Navy's overall approach to ordnance research and development. Many readers will be interested to note how China Lake related to other efforts of naval technical bureaus to provide advanced weapons systems. Students of effective organization will be impressed by the short and direct lines of communication that allowed the Bureau of Ordnance to take a wide range of initiatives in developing China Lake with a minimum of reviews by other layers of government. The mutually supporting roles of civilian scientists and technicians and naval officers responsible for the operational employment of weapons are another central element in the history. But, perhaps above all, the authors remind us once again that in the last analysis any successful undertaking depends upon the competence and dedication of its assigned personnel.

INTRODUCTION

In reviewing this history for publication, I am indebted to my predecessor as Director of Naval History, Vice Admiral Edwin B. Hooper, USN (Ret.), and to Dr. Caryl P. Haskins, a member of the Secretary of the Navy's Advisory Committee on Naval History, for their perceptive comments. I share with these reviewers the belief that this volume will serve not only as a record of China Lake's numerous successes but also as a case study of the general process by which science and technology may be integrated into the development of modern naval forces.

JOHN D. H. KANE, JR., RADM, USN (Ret.)

*Director of Naval History and
Curator for the Navy Department*

Preface

One of the first decisions facing us as authors of this, the second volume of a historical series on the Naval Weapons Center, was to determine what time span should be covered. Volume 1, *Sailors, Scientists, and Rockets*, traced the history of rocketry and the interactions between naval ordnance and science from World War I through a sequence of events that led to the establishment of the U.S. Naval Ordnance Test Station, Inyokern, California, the predecessor of NWC. That volume ended with a brief look into the future, covering a period that extended a few months beyond the official date of the Executive Order establishing the Station. Volume 2 begins and continues the story from that same date, November 8, 1943. This slight overlap made it possible for Volume 1 to bring major streams of events involving the early history of military rockets and the founding of NOTS to logical stopping points and for this second volume to begin at an equally logical starting point, the official establishment of NOTS. One result is that the reader of Volume 2 need not read Volume 1 unless background information is desired on two important historical roots at NOTS: the history of naval rocketry and the history of military-scientific relationships in weapon research and development.

Volume 2 spans a relatively short period of the Center's three-decade existence: only four and a half years—from November 8, 1943, to May 1948—but these were crucial years. They were the formative years. They include the final, intense years of World War II when the new Station's ability to respond to urgent combat needs for the new wonder weapons—rockets—was put to the test. They also include a critical period of the Station's transition from war to peace when the issue at stake was whether the new naval facility on the

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desert would continue to serve merely as a test station, as its name implied, or whether it would become a laboratory as originally envisioned, with the primary function of "research, development, and testing of weapons." These were the years of the construction miracle that transformed the raw desert near Inyokern into the Navy's largest research and development complex for weaponry. In these few years more facilities were constructed than in the next two decades at NOTS. In brief, these were the Inyokern years. To the Navy research and development community, "Inyokern" was not only a small desert town but also the name of a grand new experiment to bring within the Navy framework its own team of scientists and engineers to develop new weapon systems.

In defining the scope of this volume we recognized that the crucible in which NOTS was shaped and tempered was not delineated by the bounds of the desert Station; rather, it had dimensions as broad as the defense of the nation itself and a depth that would influence the whole process of weapon research and development. Accordingly, we did not limit the scope to that of a local history.

Of necessity, in covering the broad picture of the Station's role in national defense we have been unable to give recognition to the many employees and associates of NOTS who gave dedicated and capable service to NOTS in the period covered. We hope they will take well deserved pleasure in seeing recognition and interpretation given to the era at NOTS to which they contributed.

Volume 2 is derived largely from the same body of research and interviews as Volume 1. This includes more than 80 taped interviews with military and civilian principals associated with NOTS in the formative years. Many of the principals who contributed so much of their interest and special knowledge earlier gave invaluable support to this second work. It is a pleasure to identify these individuals and accord them a sincere vote of gratitude:

Rear Admiral Sherman E. Burroughs, Jr., USN (Ret.)

Dr. and Mrs. Emory L. Ellis

Dr. William A. Fowler

Captain Clarence H. Haugen, USN (Ret.)

Vice Admiral John T. Hayward, USN (Ret.)

Mr. A. L. Pittinger

Captain Thomas F. Pollock, USN (Ret.)

Rear Admiral James B. Sykes, USN (Ret.)

Dr. L. T. E. Thompson

Rear Admiral Curtis F. Vossler, USN (Ret.)

PREFACE

The California Institute of Technology and the Naval History Division of the Department of the Navy have been eminently responsive to requests for archival support; and much has been necessary.

Of special importance, Vice Admiral Edwin B. Hooper, USN (Ret.), formerly Director of Naval History Division, and Dr. Dean C. Allard, Head of the Division's Operational Archives, have provided guidance, aid, and encouragement without which this history would not have been possible. Likewise it is a pleasure to acknowledge the support of H. G. Wilson and the late Dr. William B. McLean, former NWC Technical Directors, in initiating this historical project and for their continuing aid.

The Federal Records Center at Mechanicsburg, Pennsylvania, provided the long-term loan of NOTS logs—185 ledgers in all. This “treasure trove” made it possible to inject human interest into otherwise prosaic accounts.

For lack of a better statement, we repeat from Volume 1, “. . . it should be clear that like a research and development project, this history was not the creation of one man but of many.” As with Volume 1, there has been a profound collective contribution made to this work by many “early timers” of NOTS. Principally, an accolade for services rendered is extended to Dr. Hugh Hunter, K. H. Robinson, and D. T. McAllister, who reviewed final draft material and provided valuable insights. Similarly, John L. Cox, A. S. Gould, and the late James D. DeSanto applied their expertise and special knowledge of “how things were in the old days” to individual chapters, and thereby earn grateful acknowledgment.

Happily—for NWC and the history project—the list of “early timers” still serving the Center is long; less happy is the fact that limited space does not permit a mention of all who have graciously responded to telephoned or similarly informal queries. Their presence, support, and refreshing enthusiasm made the history-writing burden so much lighter, and helped to personify the fabled, friendly “spirit of NOTS” that is an inherent and a recurring theme throughout our chronicle.

The pride held by NWC for its history has been amply demonstrated by the degree of support so freely given at all levels of command, ranging from the Commander and the Technical Director down through the Center's organizational chain of command to the working level. In particular, we thank C. E. Van Hagan and Dr. Robert H. Pearson, former and current Heads of the Technical Information Department where this history was written and transformed by a

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professional publication team into publishable form. We gratefully salute all our associates of the TID team. Special thanks are extended to Florence Dinsmore, Georgia Cabe, and Jane Casey, who so capably edited the history and guided it through production; to Gayle Ammerman for her devoted effort in manuscript preparation; and to the staff of the Composition and Layout Branch of TID for their dedication in readying this volume for printing.

For assistance in chronicling the history of the outside community and the Indian Wells Valley, the authors are also indebted to Richard C. Bailey, Director, Kern County Museum, and Ardis M. Walker of Kernville.

In attempting to make this an interpretive history rather than a mere chronicling of facts and dates, our aim has been to discover and highlight the key trends, events, and problems. As the authors we accept full responsibility for these interpretations and for the content.

This volume ends with the dedication of Michelson Laboratory on May 3, 1948. The completion of this modern research laboratory assured the success of the Inyokern experiment. The laboratory was solid evidence that the Navy considered NOTS permanent and that it was going to provide a first-class working environment for its scientists. The crucial formative years were over; but this is not to say the Station had all its great challenges behind it. The years ahead would be filled with vital technical, administrative, and human challenges. It is to these challenges in a new environment of weapon sophistication that succeeding volumes of this history should be addressed.

J. D. GERRARD-GOUGH and ALBERT B. CHRISTMAN
*Technical Information Department
Naval Weapons Center*

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1

Desert Ship Under Way

Center stage in the history of the founding of the Naval Ordnance Test Station (NOTS) was shared in the last half of 1943 by Dr. Charles C. Lauritsen of the California Institute of Technology (CalTech) and Commander Sherman E. Burroughs, Jr., of the Navy's Bureau of Ordnance. In that period, as reported in Volume 1 of this series, the scientist and the young naval officer combined separate requirements for a rocket proving ground and an aviation ordnance station into one proposal covering both needs.

Acceptance of the proposal by the Navy represented for Lauritsen the clearing of the last major hurdle in the path of the large wartime military rocket program that had been initiated under CalTech through his aggressive leadership. With that achieved, he was free to shift most of his own time and attention to aid another unique weapon program that he believed would hasten the end of the war, the atomic bomb. In so doing, he left the center stage in the NOTS drama to Burroughs.

Before proceeding with that story, it will be helpful, particularly for those who have not read Volume 1, to have a brief summary of the rocket work conducted for the Navy by CalTech as part of the wartime Office of Scientific Research and Development (OSRD).

Simply put, before Lauritsen personally went on a promotional rampage in 1941 for an accelerated rocket program using the British example of dry-extruded ballistite propellant, there was no large-scale military rocket program in the United States. Work by Dr. Robert H. Goddard, extending back to the pre-World War I era, and work by Dr. Clarence Hickman and others under separate tasks of OSRD

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would eventually have their impact on the wartime and postwar rocket programs, but it was Lauritsen's demands for action that launched the main rocket effort of the United States in World War II. And it was the dramatic growth of this CalTech rocket program under Lauritsen and the resulting urgent demands for space for testing that provided the primary justification for the establishment of NOTS.

The Navy's priority program to develop CalTech's 3.5-inch aircraft rocket and put it into combat on thousands of aircraft on a rush basis was the immediate pressure triggering favorable action on the Burroughs-Lauritsen proposal for what became NOTS. But this was but one factor in the military's growing fascination for rockets at this time.

Early in 1943 the first word of German aircraft rockets reverberated throughout the United States military. Field reports were shocking to those who could comprehend the significance of the new weapons. Rare indeed were those who could foresee that rocket propulsion was an inevitable trend for weapons in the future. But what was immediately apparent was the danger of a "secret" weapon, both in psychological and tactical terms, in the hands of the enemy. One of a number of aftershocks came on November 1, 1943, at the very time the final decisions were being made on the opening of NOTS. It was a scathing syndicated article by the aviation pioneer Major A. P. de Seversky. For our purpose the title alone provides the impact and tone of the story: "Nazis New Air Rockets Caught Our Side Napping."

Along with the knowledge of the enemy's tactical rockets came classified reports on the German's secret rocket center of Peenemünde. Even the scant reports gave ordnance officers like Burroughs a clear idea of the immense military value of an isolated research and development center where civilian scientists could concentrate their talents in secrecy on the new technology of rockets.

In addition to the goading of critics and the burgeoning awareness of the enemy's advances in rocketry, there were Fleet and battlefield needs for the new weapons that were being keenly felt by late 1943. The United States had moved to the offensive in the Pacific war and urgently needed the hard-hitting power of rockets. In the age-old competition between firepower and armor, it was becoming increasingly clear that 50-caliber aircraft machine guns were decreasingly effective against improved enemy armor.

All of the above factors helped bring about a reorganization in 1943 of the rocket programs being conducted for the armed forces

by OSRD. OSRD work for the Army was transferred from the old Naval Powder Factory to the newly established Allegany Ballistics Laboratory that had initial contract support from George Washington University in much the same way that the Navy's OSRD work was done by contract to CalTech. The 1943 reorganization of rocket work endorsed the de facto arrangement whereby CalTech rocket work was primarily for the Navy. In essence, the CalTech program was the Navy's rocket program, and if it was to succeed it needed Navy support, particularly in providing test ranges and aircraft. One effect was to focus attention on the newly born NOTS as the future center for naval rocketry and on the needs of the newly promoted officer who would command the fledgling Station, Captain S. E. Burroughs, Jr., USN.

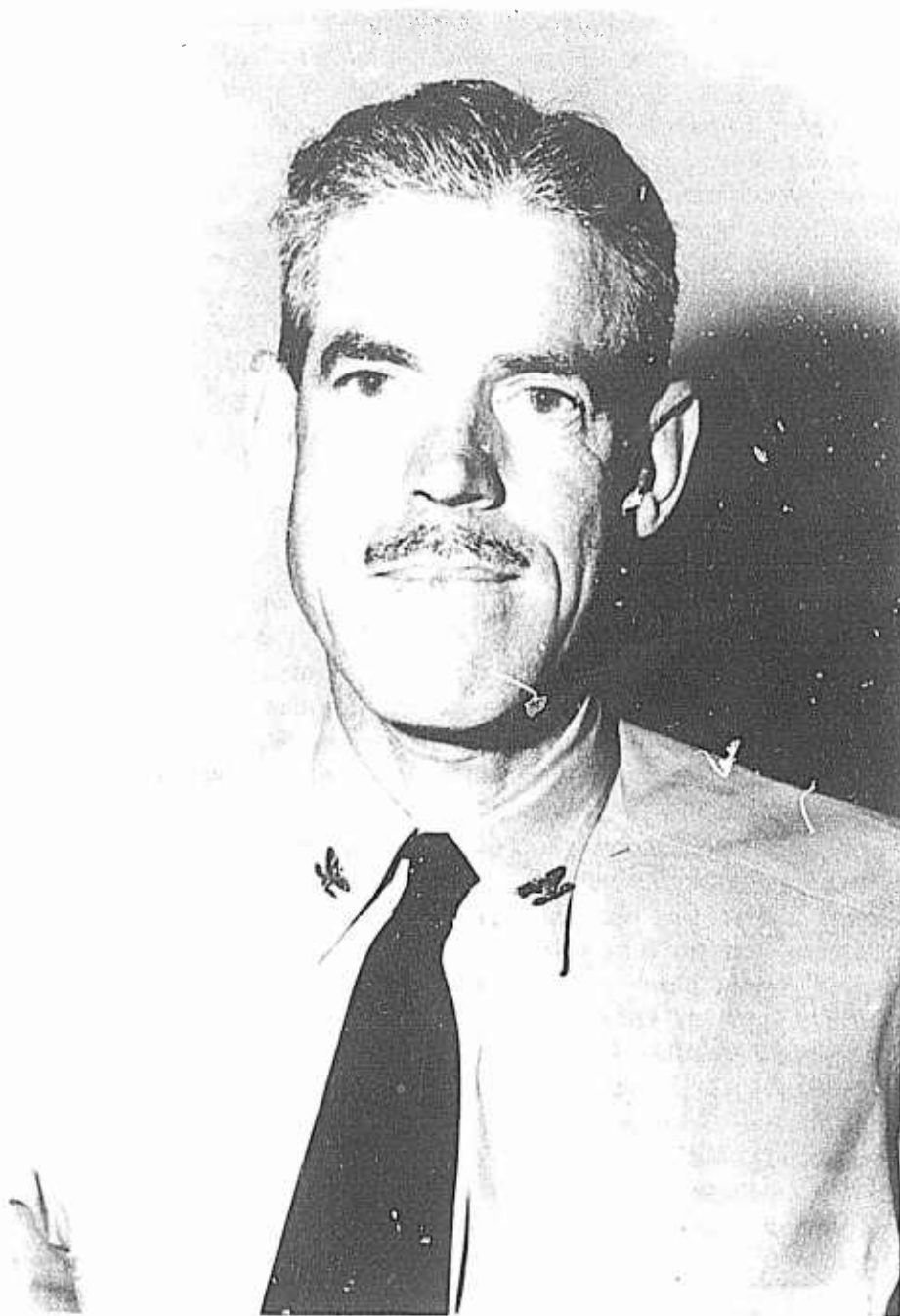
CAPTAIN ON BOARD

There was no ceremony. The young Navy captain simply arrived and took charge. So inconsequential seemed the occasion that the exact time and date were never recorded. But evidence indicates it was December 21, 1943, when Captain Sherman Everett Burroughs, Jr., took command of the Naval Ordnance Test Station.

The lack of ceremony was undoubtedly determined by the paucity of the new command itself: a remote airstrip built some ten years earlier, six Quonset huts, and a crude mess hall that had only just been hastily assembled in this desolate corner of California's Mojave Desert that the map designated "Inyokern." If a ceremony had been held on Burroughs' assumption of command, the "all-hands muster" would have produced a lean assortment of four officers and a scanty crew of enlisted men. As guests of the command it might have been possible to lure a half-dozen of the scientists and technicians who commuted to the Station from the California Institute of Technology, Pasadena, California, and perhaps a construction worker or two could have peered up from the task of assembling Quonset huts.

As he viewed the endless miles of open desert, the slender, Academy-rect captain, known as "Ev" to his associates, had much to ponder in a way that had not been possible back at the Bureau of Ordnance "aviation desk" in Washington. The Station he had originally proposed in the spring of that year, 1943, had become a reality.

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Captain (later Rear Admiral) Sherman E. Burroughs, Jr., the Station's first Commanding Officer.

An order by Secretary of the Navy Frank Knox just six weeks before had, in fact, proclaimed the U.S. Naval Ordnance Test Station "hereby established." But actually being here in command of the wilderness site gave the captain pause to consider his relationship with the new Station in a different light.

The assignment to the undeveloped desert Station with so much space and so few of civilization's amenities might expectedly have been accepted with a dutiful but aching heart. Not so with Burroughs. He wanted the Inyokern assignment as much as any naval officer ever wanted command of a ship. Standing in front of the Quonset hut that was both his headquarters and residence, Burroughs could recall the disappointment caused by the initial summary rejection of his suggestion that he command the new Station. In proposing the Station, while still at the rank of Commander, he had boldly written his superiors, "The commanding officer should be an aviator captain and I nominate myself for this job. . . ."¹ The offer had been as tersely rejected as it had been boldly offered.

Having seen his proposal for a station grow and take form, he sincerely felt that the concept might lose something in translation under the hands of others. Burroughs, a former squadron commander in combat, felt a compelling obligation to all pilots of the Navy to build a center where better weapons for Fleet aircraft could be developed and tested. Burroughs recalled that when he had left the Pacific in March 1943 for duty at the Bureau of Ordnance, Vice Admiral William F. Halsey had said to him, "Go back and get things straightened out back there! Try to get those guys off the dime!" In no sense an order to the young commander, Halsey's parting admonition was an expression of concern that naval aviation was not getting the advanced weapons so desperately needed.

As evidenced by a firmly set square jaw, Burroughs was a determined man, and the determination to upgrade naval aircraft ordnance stemmed from more than his experience of flying in combat with inadequate weapons. In addition to being a Navy pilot, he was an ordnance postgraduate and therefore a member of the elite of naval ordnance known as the "Gun Club." His wide experience in both ordnance and aviation heightened his awareness that the development of weapons specifically designed for aircraft had long been neglected. In the prewar years he and Commander (later Rear Admiral) Malcolm F. Schoeffel had tried unsuccessfully to get the funds for research in aviation ordnance greatly increased. Their failure stemmed largely from the priorities of the time whereby shipboard

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ordnance and armor claimed the lion's share of the Bureau of Ordnance's tiny research budget. Burroughs personally felt that the offensive mission of naval aviation was generally subordinated to the "eyes of the Fleet" observation role.²

Pearl Harbor drove home a hard lesson in naval air strike warfare. And this lesson—together with others in the widening theaters of World War II—dramatically rearranged priorities and pointed up the need for superior aircraft weapons. Coming back from the Pacific, Burroughs had felt that the time was right to strike hard for new technological emphasis on these weapons.

In December 1943, here on the undeveloped desert near the village of Inyokern, he knew the time was indeed right. The reconsidered decision had placed him in charge of the new Station. He was in a unique position to strike a blow for better aviation ordnance.

The snow on nearby Mount Owens of the Sierra Nevada reminded the captain it was but a few days until Christmas. It would be another Christmas away from his wife Kay and their two daughters, who were in Washington.

In 1943, December meant more than Christmas; it meant that the war had already advanced two years on its deadly course. While it was felt that the tide had turned in the battle for control of the sea—as a result of the Solomons campaign and the Battles of Midway and the Coral Sea—nobody doubted that a determined enemy would fight with even greater ferocity now that he was being forced into a defensive role.

The war was more than a morning headline; it loomed behind every discussion, every justification, every decision of Burroughs and others in ordnance. In considering every major action, the ever-present question was, What will be the effect on the war? The projected effects were often perceived to be quite different by the separate individuals when it came to developing and testing new weapons and in constructing facilities for experimental work. As a result, there were many administrative battles when it came to implementing the plans for the new Station. In Burroughs' mind the two kinds of battles were inseparable, marked indelibly by the recollection of machine guns that jammed under the high g forces of aerial combat; and the memory of the torpedo pilots who had died to deliver "fish" that failed to explode when they hit enemy ships.

The war—particularly the air war in the Pacific—was clearly in the mind of the new Commanding Officer when, without ceremony, he

assumed command of NOTS. In the administrative battles ahead, the sustaining force would be his deep feelings of the urgency and importance for giving the pilots of the Navy the best of weapons. In essence, he had not left behind his squadron in the Pacific.

AN EXPANDED CONCEPT

The concept of the Station when Burroughs took command in December was one that had been considerably expanded since the spring of 1943 when Burroughs first began pressing for a new naval proving ground for both testing and developing aviation ordnance.

The first expansion resulted from an informal discussion with Dr. Charles C. Lauritsen, the head of the wartime rocket development program being conducted by the California Institute of Technology for the Office of Scientific Research and Development (OSRD). Lauritsen's rocket program, particularly for the air-launched rockets, was undergoing momentous growth. Once overlooked as weapons of war, rockets were suddenly in great demand—the new “secret” weapons of both the enemy and the allies. Among other things, rockets were the new hope for giving aircraft the heavier firepower they needed. When Burroughs and Lauritsen looked at the needs of their separate programs, they saw the advantages of combining the aviation ordnance requirement for a proving ground with the CalTech need for space for rocket testing and training. Burroughs pulled the combined proposal together and presented it to his superiors in the Bureau of Ordnance, including the Chief himself, Rear Admiral (later Admiral) William H. P. Blandy. As with everything else that had happened to the charmed proposal the timing was perfect. Blandy was winding up his Washington tour in preparation for an assignment at sea, and he was concerned that what he had learned in his tumultuous years as the Bureau Chief could be lost. Above all, Blandy was a man of foresight, so while others were considering the next battle, he was concerned about the next war. Having led efforts to make the old peacetime Bureau responsive to the needs of global war, Blandy in late 1943 had a different concern, that of using some of the wartime momentum and insights into securing a continuing naval research and development effort in peacetime.

In the midst of the deadliest war in human history, Blandy was deeply concerned with postwar planning. In his final report as Bureau Chief he stated, “In the postwar period, which, of course, will also be

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Dr. Charles C. Lauritsen, head of the California Institute of Technology rocket program.

the next prewar period, determined efforts must be made to maintain the contact now existing between the Bureau of Ordnance and the best scientific brains and research facilities in the country."³

The role of government laboratories and their contracts with educational institutions and private industry concerned Blandy. He felt that developing these ties should rank high in planning postwar programs because "Ordnance more than other naval activities needs this special attention to research, because, unlike ships, aircraft, communications, etc., it has no counterpart in civil life, and thus derives little from developments springing from the normal pursuits of the people in time of peace."⁴ Blandy's analogy likened the nation's postwar needs to that of adequately manning and rearming a fort after every siege. This reasoning was based on past history where the traditional national retrenchment and inevitable reappraisal of military priorities that usually followed a war would most likely preclude the building of an adequate peacetime ordnance development establishment after hostilities ceased.

It was while Blandy was preoccupied with long-range plans for Navy research and development that the Burroughs-Lauritsen proposal was presented to him.

On important decisions Blandy's management style was consistent; so it is safe to presume that when the proposal for a new ordnance station was made, Blandy met with the key personnel in the Bureau who had a stake in the venture. In his typical style, Blandy would have asked each for his opinion and then have taken these inputs into account in forming his own position. Then all would have turned an eager ear to hear from Blandy what the Bureau's position would be. They would hear that eventually the Station should be adequate to conduct research and development for all forms of naval ordnance, but for the immediate future the emphasis would be on the testing of rockets and other weapons for aircraft.⁵

Blandy's impact upon the concept was to switch the long-term emphasis, although not the immediate priority, from the wartime needs that preoccupied Burroughs and Lauritsen to the broader concept of a permanent research and development center for ordnance that would serve the Navy's needs in both war and peace.

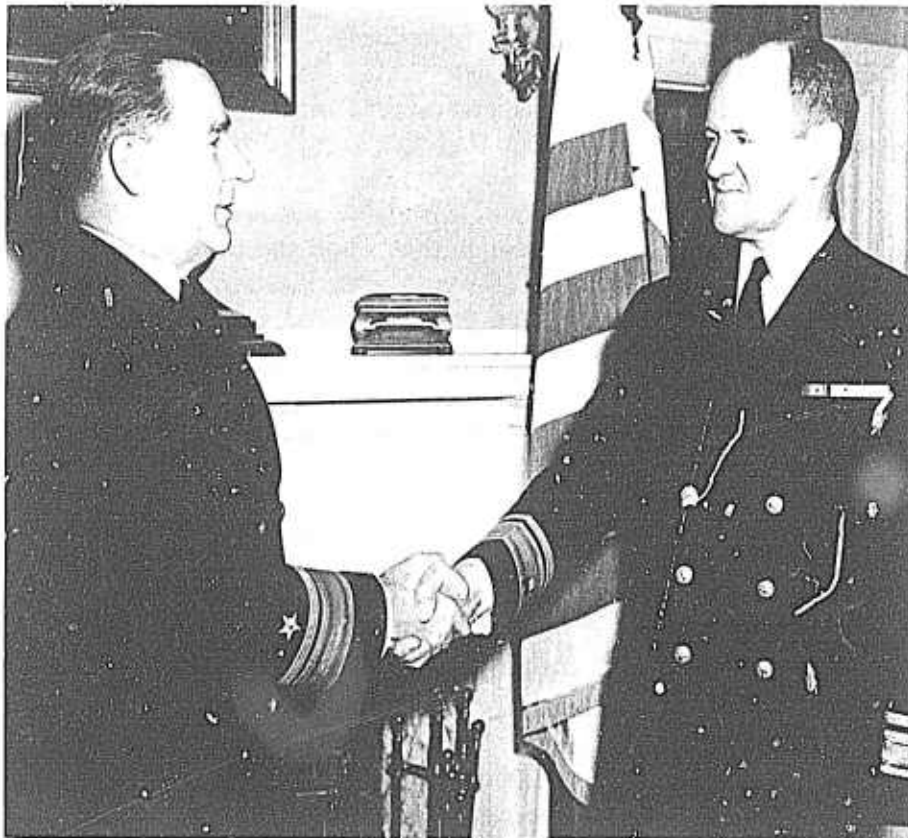
The broadening of the concept had been taken one step further by November 8 when the Secretary of the Navy, Frank Knox, signed the order establishing the Station. In that order, the mission statement did not make reference to the station working on any particular type of weapon. But it was clear when Burroughs assumed

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command that the priority on the work would in fact, if not in words, be in getting rockets and improved systems of aviation ordnance into combat. It was up to Burroughs not only to meet the immediate needs as perceived by him and Lauritsen but also to work toward the enlarged concept that had evolved.

Blandy left the Bureau of Ordnance for Fleet duty less than a month after NOTS was founded. Fortunately for the Station and naval ordnance in general, Blandy's successor, Rear Admiral George F. Hussey, shared the same enlightened philosophy toward weapon research and development.

Following his appointment on December 10, 1943, Hussey faced the enormous job of providing the Navy with the weapons it needed



A new Chief for the Bureau of Ordnance: Rear Admiral W. H. P. Blandy (left) is relieved by Rear Admiral G. F. Hussey, December 10, 1943.

to win the war. But, like Blandy, he saw the need to build for peacetime. He saw his wide-ranging responsibilities as also including parenthood to the fledgling desert Station. He would closely watch its formation in faraway California and provide the necessities for its healthy growth and future development.

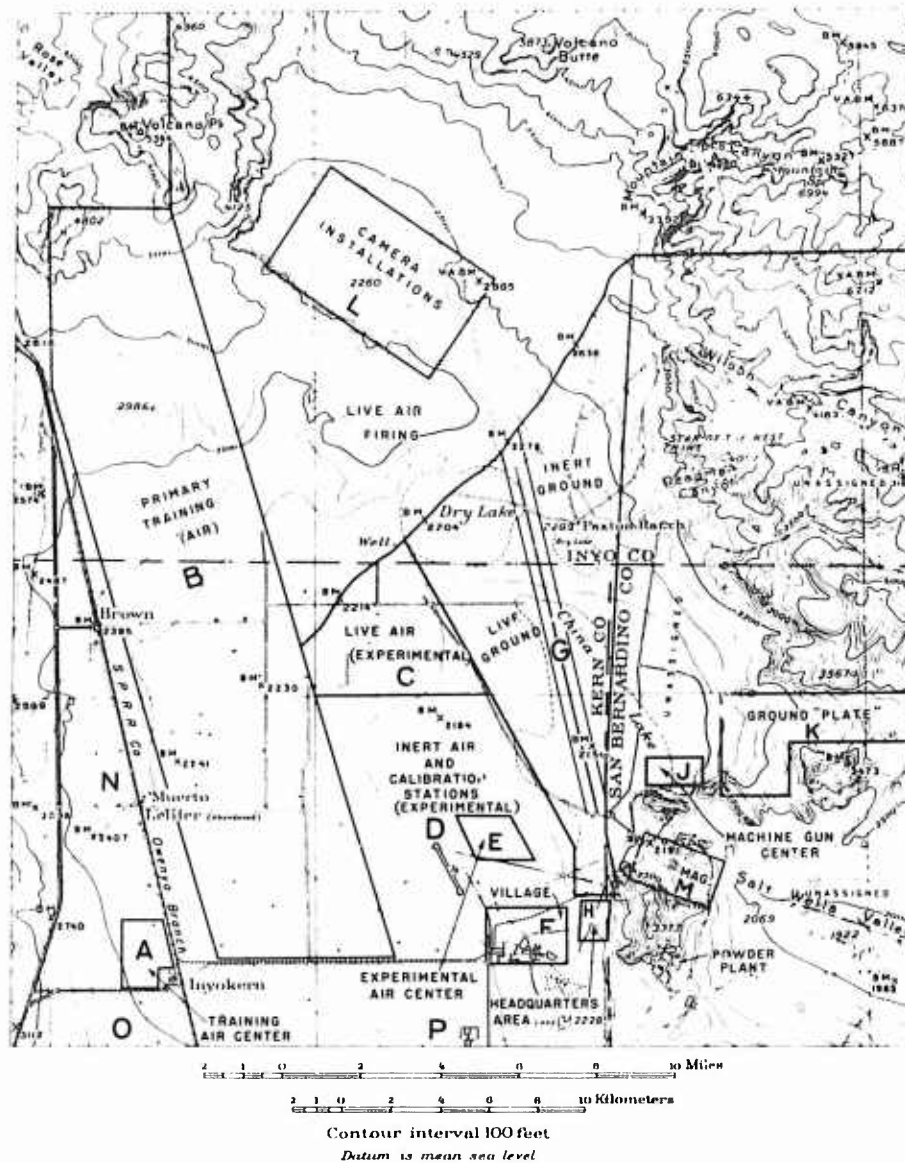
For four action-packed months, mid-December 1943 to mid-April 1944, Burroughs maintained the Station's headquarters in the combination office-bedroom Quonset hut at the Inyokern airfield.

The office was crude and the living accommodations equally coarse, but they provided the epitome of efficiency for a man who needed every moment he could muster for the staggering job of simultaneously building and operating the new Station.

In those first four months that the headquarters was at the airfield, Burroughs was able to add sporadically to the number of enlisted personnel and to the original officer complement that had consisted of Lieutenant Commander David E. Saunders, Officer in Charge, Inyokern airfield; Lieutenant Commander Jim Tom Acree, Executive Officer (Acting); Lieutenant Richard W. Henderson, Supply Officer; and Ensign Ardell L. Cody, Aircraft Maintenance Officer.

Starting with these officers, Burroughs immediately began delegating responsibilities. But no matter how the tasks were divided and subdivided, all pieces had to fit together in Burroughs' mind. Others could worry within the confines of individual problems: aircraft operations; ground range facilities and rocket testing logistics for training squadrons; construction of ranges, a new airfield, laboratories, housing, shopping facilities, roads, and utilities; personnel; acquiring the land; management; and funding. Burroughs had to fit all these into one comprehensive and meaningful framework so that he could judge progress, schedule work, and identify bottlenecks. He had to be concerned not only in meeting the immediate wartime needs but also the long-term need for a permanent research and development center. So many things had to be done; most cried out for immediate action. There could be no waiting to acquire the land before building at least the most critical facilities on it. There could be no holding back of the testing and of the training operations until permanent facilities were built. This was war. Just as Burroughs in combat had displayed excellent judgment and cool courage in the face of heavy enemy antiaircraft fire, he faced with steady determination the needs at NOTS for simultaneously starting air and ground operation, land acquisition, construction, and the planning and development of the future research and development laboratory.

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Courtesy Millikan Library, California Institute of Technology

Tentative map of NOTS Inyokern, 1944.

OPERATIONS

Burroughs did not have to start the NOTS rocket testing operations. In a style fully characteristic of the new Station, they had been started before his arrival and within less than a month of the official establishment of the Station.

A few days before November 16 when the Bureau of Ordnance, CalTech, and NOTS planners had finished drawing up their "wish list" for facilities, Dr. Emory L. Ellis of CalTech had started on his way to Inyokern to direct the start of work on the ranges. Accompanying him in a CalTech four-wheel-drive vehicle were two of the Institute's staff members: Calvin Mathieu and Burnham Davis. Their job was to stake out the flight lanes for rocket tests that would take place four weeks hence. All had the foresight to take sleeping bags along.

When they arrived at the NOTS site, the magnitude of their task was immediately apparent in the vast expanse of raw desert. Nevertheless, there was hope in the person of Chief Carpenter F. J. Snyder, whom Ellis described as "the only Navy man in this whole valley." There was evidence, too, that the massive Navy machinery for building a new shore establishment was slowly beginning to grind in the form of a 40-man civilian construction crew, bulldozers, and a cookshack at the Inyokern airfield where Ellis and his companions managed to get a meal.

Ellis describes his accomplishment:

Our problem then was to stake out these flight lines and get them marked by bulldozer, so that the pilots could find them. Also we needed to get a barricade bucked up so that we could put a field radio transmitter and some observers behind this safe embankment because these were high-explosive tests. . . . We got the bulldozer operator pointed toward a mountain up there and told him to drive . . . straight ahead through that country for about eight miles until he came to a road. . . . We said, "Now you turn left and you go down the road until you come to the yellow flag and then lay out the line along the lath." . . . So he started out across country in that bulldozer and the next morning we went out and he'd bladed that line out and was busy clearing a rectangular area which was the impact area.⁶

Thus, the first aircraft range at NOTS—Charlie Range (C-1)—was marked indelibly in the Indian Wells Valley. A white cross designated the 200-yard-square impact area. NOTS was now ready for the first "shoot." Other similar ranges would just as quickly come into being, notably, one to the west of Charlie Range that would serve the horde of Fleet squadrons whose arrival was imminent.

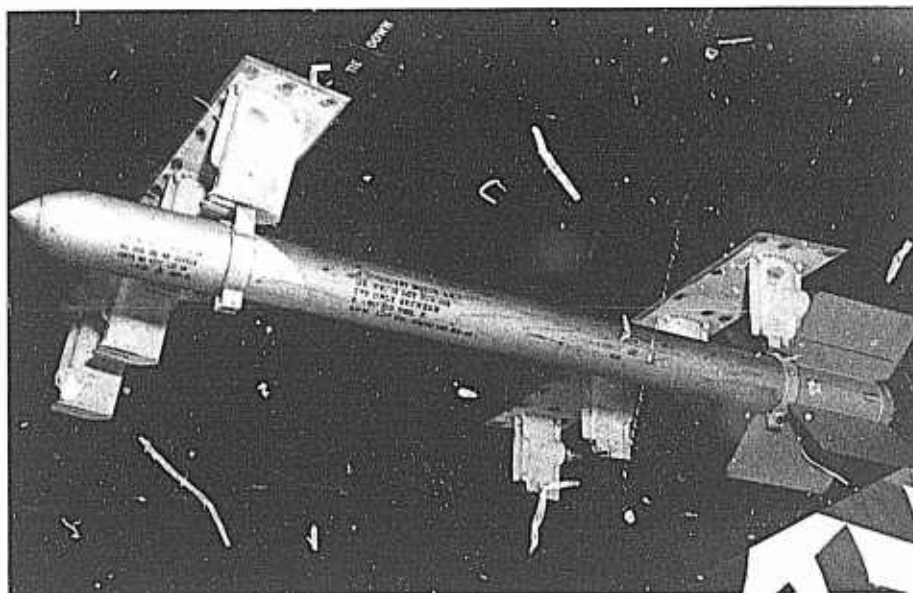
As Ellis' personally directed bulldozer was marking the aircraft ranges, another was reshaping the desert to the east on what was to

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become the ground ranges. These ranges (G-1 and G-2) were more elaborate than the aircraft ranges as they required telephone lines, spotting stations, locations for special instrumentation camera, and detailed test equipment.

The rush to put the NOTS ranges into operation was based on urgent needs. The Navy's priority expansion of the 3.5-inch forward-firing aircraft rocket (AR) program was creating demands for more tests than could be accomplished with the limited facilities and space available to CalTech at Goldstone Lake, the test area they were using near Barstow, California, on part of the Army's Camp Haan (later Fort Irwin).

The first NOTS test featured the 3.5-inch AR with a high-explosive head instead of the original solid-steel shot head. The fact that the rocket was not fully satisfactory because of insufficient high explosive was not clear in December 1943 when it became the first rocket tested at NOTS. The purpose of the historic tests was to help solve some problems concerning instantaneous nose fuzes that were in production but were causing an unacceptable percentage of duds.



The 3.5-inch aircraft rocket: the California Institute of Technology's first forward-firing aircraft rocket.

In the terse style of a technical report, the event was recorded:

Forty rounds of 3.5-inch AR Model 9 were fired from two SBD airplanes at Inyokern [December 3, 1943] . . . to test the functioning of the Mk 148 fuze on a land target.⁷

The December 3 firings not only marked the beginning of operations at NOTS, but also provided some answers. They indicated that the 30% malfunctions were probably caused by the arming wires staying with the rounds on firing. These data were typical of the kind of critical information the NOTS ranges began to supply weapon developers.

Fuze tests predominated in the NOTS tests of early December. But there were other kinds of tests. Some led to improvements in the rockets. Some pointed to the need for strengthening structural members of the aircraft. Others proved the capability of firing rockets at night and under different flying conditions. All led to the matter-of-fact acceptance of NOTS Inyokern, limited though it was, as a promising frontier where the pervasive problem of finding space to test rockets would be solved, finally.

AIR SUPPORT

The role of air operations—the planes and the men who flew them—is an inseparable part of the NOTS story.

The air operations for NOTS were a continuum of CalTech's rocket testing activity at Goldstone Lake and other interim facilities. It had all started in San Diego in April 1943 before NOTS was proposed and stemmed from CalTech's desperate need for pilots and aircraft to pursue their program of aerial rocket experimentation and development. But combat aircraft in war are scarce indeed for anything but operations or training. Lauritsen found this to be true in attempt after attempt to obtain aircraft from operating levels of the Navy. But with each refusal his determination grew, and the level of the request went higher. Finally he reached a sympathetic hearing from Captain (later Rear Admiral) H. B. Temple; Temple happened to be U.S. Fleet Commander in Chief Admiral Ernest J. King's staff head for antisubmarine warfare. Through "Brownie" Temple's intercession, the Commander Fleet Air, West Coast, Rear Admiral (later Vice Admiral) Charles A. Pownall, directed his energetic Gunnery Officer, Commander (later Rear Admiral) Jack C. Renard, to establish a small experimental unit exclusively for the air support of CalTech. As Renard was also Commander Fleet Air's (ComFAir)

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Assignments Officer, he was able to select a particular individual to head up the new unit: Lieutenant Commander (later Captain) Thomas F. Pollock. Pollock had recently completed a distinguished tour of combat duty in the Pacific, but his candidacy was assured when Renard learned how Pollock, who was awaiting reassignment, had contrived to go on a flight test of a MAD/retro-rocket against a submarine. MAD (magnetic anomaly detector) was a sensor mounted in the aircraft that detected changes in the earth's magnetic field caused by submarines or other ferrous objects and even variations in the earth's own magnetic field. Developed before the war by Gulf Oil Research Laboratory, it was turned into a submarine detector through additional defense programs sponsored by the U.S. Navy and OSRD. Renard considered anyone so fascinated with the new wonder weapons was obviously a candidate to head the first unit of aircraft for experimental testing of rockets.

The Hedron 14* Experimental Unit was informally organized in San Diego starting with one airplane (a TBF), one pilot (Pollock), and one mechanic (Bill Edward Camp†). Within a month the unit's complement had been augmented by four more personnel,‡ and a PBY airplane was acquired.

A major function of the unit during April and May 1943 was to test MAD equipment in PBY and TBF aircraft in conjunction with retro-rockets.⁹ At the same time some limited testing was done in support of the (as yet) unauthorized experimental work CalTech was doing on forward-firing rockets. This was a foretaste of things to come. But what came was not a gradual, foreseeable flowing of the tide, but a sudden, dashing tidal wave. No sooner had the effort on forward-firing aircraft rockets gotten afloat than it was hit by the overpowering demands of the massive rocket program initiated by the "June 7 ComInch memorandum." Renard recalled the circumstances later:

Once Admiral King and his staff knew we had a real thing—a thing that we could really progress in and turn out quick—then they were on our back. Get going; not today, we want it yesterday.¹⁰

* The name "Hedron 14" derives from its parent organization—Headquarters Squadron 14. This squadron supported Fleet Air Wing 14 located at the Naval Air Station, San Diego, under ComFAir, West Coast.⁸

† AMM1/C Camp was transferred to NOTS in November 1943. In 1959, after a distinguished naval career, he transferred to civil service and at the present time is employed as a planner and estimator in the Center's Public Works Department.

‡ Lieutenant (jg.) Rodney L. [unclear], CHRE Harry C. LeGoube, ACRM James E. Barnes, and AM1/C Harry J. Amos, Jr.

DESERT SHIP UNDER WAY



Lieutenant Commander (later Captain) Thomas F. Pollock, NOTS test pilot and head of the Aviation Ordnance Development Unit 1.

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Ever increasing numbers of Fleet squadrons were to be equipped with the new rockets and launchers. On October 19, 1943, the Vice Chief of Naval Operations issued a jumbo order for 6,000 planes to be so equipped by June 1, 1944.¹¹ Of this number, 4,500 were earmarked for the Pacific Fleet. Responsibility for these fell squarely in the lap of ComFAir, West Coast, but the brunt of the work fell on Lauritsen's scientists for development, Renard for coordination, and Pollock's Experimental Unit for testing.

Thanks to Lauritsen's prodding for aircraft support, Rear Admiral Pownall had anticipated the big drive for rockets earlier when he formed the Hedron 14 Experimental Unit in April 1943. He continued enthusiastically to provide for the "expeditious pursuit of the development" until August 6, when he was succeeded as ComFAir, West Coast, by Rear Admiral Marc A. Mitscher.

Mitscher was just as enthusiastic about the new weapons as his predecessor. He had just returned from a "hot" war in the Pacific as a carrier division commander and as Commander Aircraft Solomon Islands (Guadalcanal). He was particularly aware of the aircraft rocket's potential. As Renard put it:

...it didn't take a hit over the head for [Mitscher] to grasp this immediately...he was an operational man...from an operational point of view, boy, it didn't take him two minutes to see [that] if he had this weapon, his firepower increased a hundredfold...he wanted it because he knew he was going back to sea...he wanted rockets on his planes.¹²

AODU-1

Mitscher was not alone in his enthusiasm for rockets. In a remarkable conversion at this point in history, many officers in the Bureau of Aeronautics and ComFAir, West Coast, recognized that the forward-firing rocket could revolutionize aerial warfare. Again the timing for NOTS was just right. Not only was it established at the peak of the rocket demand, but also when the importance of aircraft support was proven.

When NOTS was established no one in authority any longer doubted air operations were essential to the accomplishment of the Navy's mission. Consequently the scope of air support was visualized on a scale far beyond the already strained capability of the Hedron 14 Experimental Unit. This group had done a magnificent job, and although its personnel complement had grown in six months from the one-pilot, one-mechanic, one-plane outfit to 16 officers and 103

enlisted men,¹³ the planned air operations at the new test station implied a force more than double that strength.

The requirement for a large-scale operating air unit was translated into action on December 3, 1943, when the Chief of Naval Operations (CNO) directed the Commandant, Naval Air Center, San Diego, to establish an aviation ordnance development unit "on or about 15 December 1943." The unit was to be temporarily assigned to the Naval Air Station, San Diego, but was to be permanently assigned to the Naval Ordnance Test Station as soon as facilities were available.

The name of the unit, "Aviation Ordnance Development Unit 1 (AODU-1)," showed that CNO was planning ahead. Eventually, Aviation Ordnance Development Unit 2 was established on the East Coast to provide similar support for ordnance experimental work in the East.

The Chief of Naval Operations called for ComFAir, West Coast, to transfer ordnance development personnel, including those of Hedron 14, to the Aviation Ordnance Development Unit.

On December 21, 1943, AODU-1 was officially commissioned at the Naval Air Station, San Diego, as an activity under the cognizance of ComFAir, West Coast; Pollock was in charge. Twelve days later, on the morning of January 2, 1944, the first contingent of 10 enlisted men departed for Inyokern by plane.¹⁴

The plan called for AODU-1 to be permanently assigned to NOTS "as soon as facilities were available." That happy state of affairs was not reached for another six months. But in the meantime, there was a gradual move, made by increments of personnel and equipment, to occupy the Quonset huts and temporary facilities that were feverishly being erected at the Inyokern airstrip.

The commissioning of AODU-1, coming as it did with the establishment of NOTS in late 1943, marked the end of the old struggle of Lauritsen and his rocket developers in obtaining aircraft to conduct tests. Within the year aircraft support had evolved from the pleading stage to that of continuous support on the flight line.

ROCKET TRAINING FOR FLEET SQUADRONS

The aircraft and equipment for AODU-1, whose mission of air support to the rocket experimental work was integral to the NOTS mission, arrived at Inyokern at a slow pace starting in January. By contrast, the arrival of the Fleet squadrons for rocket training, which

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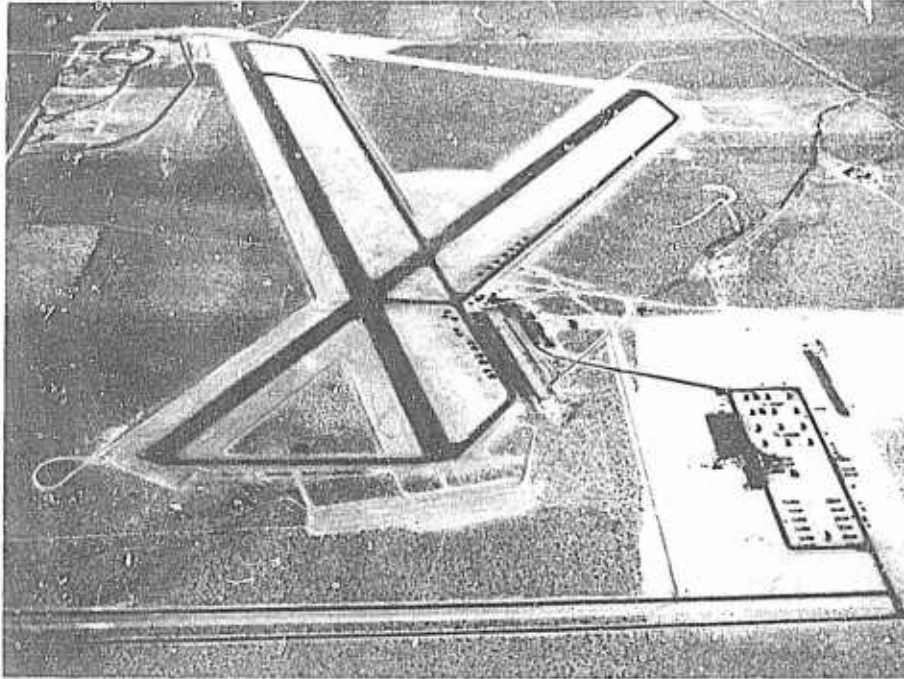
was secondary to the Station mission, was quite like that of a swarm of wasps. Inyokern was but one stop on their journey to combat in the Pacific. Pilots and aircraft were combat ready. At Inyokern their mission was to simulate diving attacks on imaginary targets and to fire their 3.5-inch and 5-inch aerial rockets at a white cross on the desert floor. Facilities ready or not, the first Fleet squadrons swarmed into Inyokern in January 1944 with the latest torpedo bombers, submarine-hunting TBFs and TBMs, in their Fleet color trim of "semigloss sea blue on surfaces viewed from above and non-specular insignia white on surfaces viewed from below."*

The two-month old Station was unprepared to cope with the new burden. While the Inyokern airfield boasted two adequate hard-surfaced runways for aircraft takeoff and landing, gasoline supplies and refueling facilities barely existed. Hangars, maintenance shops, storehouses, assembly buildings, and magazines had not been completed; neither had the barracks, shower and latrine building, or galley and mess halls. Such working and living facilities as had been built were barely enough to accommodate the handful of officers, enlisted men, and CalTech representatives that comprised the first permanent staff of NOTS. Each new squadron that arrived meant that the overtaxed resources of NOTS had to bear the additional load of men and machines, averaging some 40 crew members and 14 aircraft per squadron.

The large presence of the Fleet squadrons added to the pressures of AODU-1 maintenance personnel who faced a round-the-clock duty of servicing the tenant planes in addition to their own; a brutal task performed in the open without the benefit of hangars or workshops.

Some ordnance officers at NOTS and in the Bureau of Ordnance had seen experimental work squeezed out by the pressures of training in the past, and now saw heavy training as a threat to the primary research, development, and testing function of NOTS. The rocket developers themselves, the CalTech scientists, did not share this view. They felt the Fleet squadrons offered a valuable opportunity for a meaningful dialogue between weapon developers and weapon users. C. C. Lauritsen, in particular, considered this a good way for the technical staff to learn firsthand about the unforeseeable little

* The Grumman TBF (popularly known as the "Avenger") was a single-engine, midwing torpedo bomber. The designation TBM was used for the same aircraft produced under contract by the Eastern Aircraft Company of General Motors.



Inyokern airfield in early 1944.

problems that could sabotage an otherwise sound advancement in weaponry.

Burroughs stood midrange between the extremes. As an ordnance postgraduate, he cherished the dream of a permanent research and development center; as a former combat pilot, he knew the critical importance of adequate training in the use of new weapons. He did not question Fleet training per se at NOTS; rather, his concern was, "How much training?" And "What type of training?" In earlier discussions during the Station's planning phase, it had been implied that training would be given to but a few to make them instructors in rocketry; they, in turn, would train the bulk of combat pilots in the new science of aerial warfare.

But in January 1944, the problem was no longer philosophical; it was tangible and real. No one at NOTS or the Bureau of Ordnance had a better solution to Mitscher's training problem, but some actions could be taken to minimize it. Burroughs asked the Bureau of Ordnance if it could arrange for some means of servicing the Fleet aircraft without absorbing the time needed by AODU-1 to maintain its own aircraft for the rocket testing. Reflecting the Bureau's early

paternal concern for its new Station, Hussey pressed for separate and additional aircraft maintenance support for the Fleet squadrons undergoing training.

AIRCRAFT SERVICE UNIT

On February 15, 1944, Carrier Aircraft Service Unit (CASU) 53 was ordered commissioned by the Chief of Naval Operations and stationed at the Naval Ordnance Test Station. Its mission was to "take care of the needs of the Training Squadrons."¹⁵

On paper, CASU-53 was to have a standard personnel strength to support a 90-plane carrier group: 31 officers and 617 enlisted men. This complement was to be drawn from ComFAir, West Coast, with the equipment and material supplied by the Bureau of Aeronautics.¹⁶ In actual fact, when the Unit was commissioned at NOTS on February 24, only 3 officers, 6 aviation machinist's mates, and 100 recruits were present. (As Burroughs was initially understaffed, he applied his command prerogative and "shanghaied" 70 of the latter number.) In addition, the maintenance equipment inventory of the new Unit was woefully small.

Limited personnel was but one handicap of the Unit. Facilities were limited. Working conditions on the flight line varied with weather and there seemed to be no doubt that whoever initially selected the site of the Inyokern airfield picked the windiest spot in Indian Wells Valley. Getting needed parts flown in from San Diego, nearly 200 air miles away, was an ever-present problem. Just getting an adequate supply of aviation fuel was in itself a major challenge. Two trucks from the Marine Corps Air Station at Mojave, 50 miles away, brought in the fuel, but the daily consumption was greater than the capacity of the trucks. According to the officer in charge of CASU, Lieutenant Commander Harold H. Randecker, it regularly happened that a half-filled truck had to be dispatched to Mojave for filling so there would be sufficient fuel for the next morning's flights. As Randecker reported, "The visit of a Liberator, or the break-down of either truck, was all it took to drive the CASU to near-distraction."¹⁷ But thanks to the two trucks, constant night work, and legerdemain, CASU kept the rocket training planes of Inyokern flying.

The career of the Carrier Service Unit at NOTS was relatively short-lived--barely six months, ending in August 1944 when it was

transferred to the Naval Air Station, Holtville, California. But these were critical months as they covered the peak of the training for the operational squadrons of which 28 Fleet and one Army Air Force Squadron were trained between January and July 1944.

But the brief sojourn of CASU-53 at Inyokern during the first few hectic months of the Station's career gave more than a badly needed "hand at the pump." Like AODU-1 and the visiting Fleet squadrons, it helped lay the foundations of what would become NOTS' own Naval Air Facility.

LAND ACQUISITION

"Worthless desert land" was the description generally applied to the area by those who had reconnoitered it by air and land in the summer and fall of 1943. But by the time Burroughs assumed command in December, it was quite clear there were some people who for quite diverse reasons felt it was far from worthless.

The first volume of this series describes the problems of obtaining permission to use the land and the airstrip for the duration of the war. But this was only half the battle. For NOTS to be a permanent research and development center, as called for in the mission, it was essential that the Navy acquire clear title. To put millions of dollars into facilities and to stake out a large share of the future of Navy research and development in weaponry on land that could be withdrawn did not appear reasonable to Burroughs nor to the Bureau of Ordnance leadership.

Whatever had been their hopes for resolving the land problem promptly, these soon disappeared at the time Burroughs came on board, and the complexities and intensity of the problems became apparent.

Some of the land was in the public domain; other parcels had been homesteaded. There was land claimed for mining, and even for curative mineral baths. Cattlemen held grazing rights on some critical land areas. The legal difficulties attendant to acquiring the various properties were often compounded by questions of easement, airspace, and mineral rights. The Navy negotiators faced a wide spectrum of claimants including private individuals, companies, and other government agencies.

The most immediate problem to be resolved concerned a sister service, the U.S. Army, who held a strong prior claim on the

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Inyokern airfield. This unpretentious two-runway airfield was originally built in 1933 under the National Recovery Act by the County of Kern with the assistance of the Civil Aeronautics Authority. On September 2, 1942, the Interdepartmental Air Traffic Control Board, formed a year earlier by President Franklin D. Roosevelt to resolve land claims by military and civilian aviation groups, approved the assignment of the Inyokern airfield to the U.S. Army Fourth Air Force for use as a dispersal field and a glider school, which never materialized. The lease issued at that time gave the government exclusive use of the property for the duration of the national emergency plus six months.

Apart from resurfacing the runways, the Army had not implemented any plans for the use of the airfield. Through the persistence of Admiral Mitscher, and considerable bartering among the services, the Interdepartmental Air Traffic Control Board on October 29, 1943, reassigned the use of the airfield and the adjacent "danger area" near dry China Lake to the Navy for experimental test operations. This was an acknowledgement that, among the various possible government uses, the Navy's needs should be recognized and supported. It was also a clear signal that plans and work could be started on the Station, but one that left the question of title unresolved.

Similarly, only a temporary solution was found for the problem of acquiring the large tract of land needed for the ranges, the Station headquarters, and the community. Fortunately, most of the original area planned for the new Station was in the public domain. Also, considering the vastness of the first claim (estimated to be 650 square miles), relatively few people were involved. Burroughs reported that only 27 people were actually moved from the area encompassed by the original claim. Despite the limited number of people involved, the problems incurred by their dispossession were complex, and in some cases, personally distressing.

The process of acquiring lands efficiently and with minimum stress on their proprietors demanded a close working relationship between NOTS and Navy offices, particularly the Bureau of Ordnance and the Bureau of Yards and Docks. The cooperation of all these with the Department of the Interior was also essential. This latter relationship in respect to NOTS, although never antagonistic, was not close.

The Secretary of the Navy on December 31, 1943, requested "that the Department of the Interior take the necessary action to

transfer complete control and jurisdiction over all of the public domain lands in the area described . . . to the Navy Department and that all revocable permits affecting such land, in favor of private parties, be cancelled."¹⁸

The Department of the Interior had a different point of view. Since the beginning of the national emergency, the Department had been assailed by ever-increasing demands of the military services for vast tracts of the public domain. Although the Department recognized how essential it was to meet these wartime needs, it also believed that it was in the public interest to preserve the means for reversing the trend after the war.

As sound as the policy might have been for the lands used for wartime training and maneuvers, it did not take into account the need for a permanent weapon research and development center. This was the first of the Navy's many unsuccessful efforts in succeeding decades to convince other agencies of government that NOTS was being developed and would continue to be supported as a *permanent* research, development, and test center.

The humble cow presented one of the biggest land problems of the wartime years. When the Navy came to the Indian Wells Valley, a few stockmen held Department of the Interior grazing licenses for some of the public lands planned for inclusion within the military reservation. The stockmen protested the impending loss of these rights to Congress. To satisfy them, the Navy agreed to allow grazing in specific areas. The animals were allowed on the land at the owner's risk, and prior permission was to be obtained to enter the area for roundup, feeding, branding, or any other purpose. By the end of the war only about ten stockmen still operated under this agreement. However, despite their small number, they complicated the Navy's attempts to have the land transferred under its exclusive control. The arrangement, for example, led one commissioner of the General Land Office to conclude:

Inasmuch as your Department proposes to permit grazing on these lands to continue under the jurisdiction of the Department of the Interior and apparently will make only intermittent or seasonal use thereof, it would appear that the primary jurisdiction over the lands should remain in this Department.¹⁹

The commissioner proposed that when the Navy desired to use that portion of the ranges occupied by cattle, the cognizant ranchers should be notified early enough to round up and remove the stock in time for the Navy to proceed with the tests. The proposal was received with profound dismay by Burroughs and project managers

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who were planning complex tests with rockets and other weapons. Tests of untried weapons from fast-moving aircraft required scheduling flexibility and buffer zones free of people around target areas. The same managers could visualize long test "holds" during which aircraft, range instrumentation, and hundreds of test personnel would be kept idly waiting for the word that the last cow had exited the danger area.

Those familiar with the past history of ordnance perhaps saw the ordinary cow again changing the history of Navy proving grounds as it did in 1918, when civilian litigants claimed that a cow was severely traumatized by a shell that exploded on its grazing pasture. Molly Skinner, the cow's owner, complained to the Navy Department that the frightened animal had refused to give milk since the incident. As reported in the Dahlgren Laboratory's history, the affair was satisfactorily closed when the Naval Proving Ground's Commanding Officer purchased the cow for \$30.00 and had her transported by barge to a farm near the Proving Ground.²⁰ Despite a certain retrospective humor in this incident, it dramatically illustrated the need for longer firing ranges and was instrumental in bringing about the eventual move to Dahlgren, Virginia.

But NOTS was not an old proving ground. It was the new hope of the Navy for a place where, finally, there would be sufficient space to conduct all manner of experimental work. If nothing else, the prospect of handling the cows through a mixed chain of command—from NOTS headquarters, to Interior Department officials, to stockmen, to cowboy, and ultimately to cow-hardened the Navy's conviction as to the necessity of obtaining exclusive control over the land vital to its operations.

The first land acquisition of 650 square miles seems to have met comparatively little resistance from the mining interests. This was probably because the Station's confines at the northern boundary fell short of a concentration of mining claims in the Coso and northern Argus Ranges. This original boundary would have given a firing range of about 25 miles from the launching area at the south end of dry China Lake, a distance that appeared to be ample by comparison with any existing U.S. proving ground of the period. But rocketry and weaponry in general were moving at a rapidly accelerating pace by 1944. A review of the increased ranges of planned weapons already on the drawing board made it evident that not only longer ranges but also more firing ranges would be needed in the near future. This trend was becoming increasingly apparent in those first months that

Burroughs operated his headquarters at the Inyokern airfield. But as with the total bag of land acquisition problems, there was no immediate solution. Most of the land problems that he inherited upon arrival would be with him and his successors in one form or another for many years to come.

INITIAL CONSTRUCTION

Most of the early construction story is told in a later chapter devoted to that subject. The major highlights of the first months are presented here, however, because it is important to an understanding of the NOTS story to note the incredible speed with which the building was started. It is also important to recognize the difficulties imposed in those first months because of the attempt to acquire the land and to start this enormous construction job at the same time that the command had to begin air and ground operations to support the training of squadrons in the use of the new rocket weapons.

For every great cause there is a skeptic. History hints that one chief skeptic as to the long-range survival of NOTS was the man most responsible for the Station's initial construction, Captain A. K. Fogg, Civil Engineer Corps. But personal feelings had nothing to do with performance. Fogg was a dedicated naval officer who knew how to carry out orders. He had been told that, in addition to his regular position as the Public Works Officer for the Eleventh Naval District, he would be the Acting Officer in Charge of Construction for NOTS.

Fogg worked out of San Diego, and it is not certain that he ever visited the Station on which he was responsible for starting the construction. But his presence on the desert was not important, for as Head of the District's Public Works he was able to bring the wartime resources of the District to bear on the immediate problems of getting the new Station under way.

It did not appear to Burroughs that Fogg shared the same enthusiasm that was felt by ordnance officers like himself who were elated over the prospect of realizing, at last, a complete naval ordnance facility for new experimental work. As these ordnance officers and the equally enthusiastic CalTech scientists contrived plans for what seemed to be an endless list of technical facilities, Fogg was shaking his head as if thinking, "This can't go on; at the end of the war this will all fall apart."

At their working level, the two captains, Burroughs and Fogg,

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personified and epitomized the relationship that existed between their respective Bureaus, Ordnance and Yards and Docks, throughout the entire NOTS experience. While the viewpoints of the two Bureaus often differed—and their interrelationship in the building of NOTS was at times somewhat less than warm—their cooperation could never be faulted.

And so, whether or not Fogg and his associates believed that NOTS would ever be anything but a temporary wartime base, they responded diligently to their instructions to get the new Station under way. They also kept a watchful eye out for any increases in scope sought by ordnance visionaries and took pains to ensure that any enlargement was approved by a higher authority. It was easy enough for the ordnance officers to dream up new facilities and make endless additions to their "wish list," but it was up to Fogg and his staff to get them built. Their protection was adherence to approved plans.

Fogg had the position and the know-how to expedite construction of the immediately required temporary structures. He knew the system. He knew how to cut procedures short. He had the authority. By the time the Secretary of the Navy signed the order establishing the Station, unassembled Quonset huts were on railroad cars rolling to Inyokern; and contracts were drafted for construction of temporary quarters, interim range structures, and aircraft support facilities.

From the start there was a clear delineation between temporary and permanent facilities. Consequently, dual lists of facility requirements were prepared. Although this led to some confusion, it allowed the urgent work to be done immediately without getting into the quagmire of the prolonged discussions that were associated more frequently with the permanent facilities. Also, the dual list provided more time for the planning of structures for the permanent Station. In essence, the temporary structures were identified as being those for the wartime programs; for example, the CalTech test work, the rocket training program, and support of the larger-scale construction program. The permanent structures were designed according to an integrated plan for technical, administrative, and community facilities that would provide a center capable of fulfilling the continuing weapon research and development needs of the Navy—in war or peace.

The first funds for the temporary facilities were made available on October 28, 1943, immediately following the Vice Chief of Naval Operations' approval to proceed with the Station and eleven days before the official establishment of the Station. This informal

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approval cleared the way for \$160,000 from funds designated "Increase and Replacement of Naval Vessels." Instead of being used for any Navy vessel, the \$160,000 was transferred for "expedition of the rocket program" by starting construction of temporary housing, magazines, and a minimum of access roads. In February 1944, an additional \$550,000 of naval vessel funds were provided to "complete" financing of temporary facilities. The alternative to waiting for adequate funds would have meant delaying the start of NOTS and, in turn, critical wartime rocket testing.

The contract for the work performed with the original \$160,000 was let to Macco Construction Company in early November 1943. The exact date work started is not known, but Admiral Blandy in his proposal for the Station written to the Secretary of the Navy on November 2 reported that "The installation of temporary facilities is under way."²¹

When Chief Carpenter Snyder gave the word that moved the first dirt there were neither politicians nor Fleet dignitaries, cameramen, nor the press around to mark the occasion. Neither was there a historian aboard to duly record the exact date. Indications are that the work started early in November—at least the railroad cars with sections of Quonset huts were recalled as being seen then on an Inyokern siding.²² In any event, by the time of the first NOTS tests on December 3, when aircraft from the Inyokern airfield fired rockets on the NOTS aircraft range, a number of Quonset huts were assembled on their foundation in a livable, though windowless, state.²³

The short era of Captain Fogg as Acting Officer in Charge of Construction was distinguished by the astonishing speed with which temporary facilities were erected. But Fogg's contributions were not limited to expediting temporary construction. Despite his reported pessimism, Fogg's early administrative actions paved the way for fast progress in planning and constructing permanent facilities. The Bureau of Yards and Docks, responding to pressures from Captain James C. Byrnes, Jr., in the Bureau of Ordnance, sought from Fogg an overall plan for a permanent station, including specific layouts of the technical facilities and the community. A formal request for \$9,500,000 had been presented to the Congress expressly for Station construction. The ordnance officers wanted to be certain that when these funds were approved, there would be no delay in using them. Plans were needed. Admiral Blandy and Captain Byrnes in the Bureau of Ordnance and Captain Burroughs at NOTS recognized that fiscal

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and policy winds were favorable for the NOTS launching, but as men of the sea they knew that winds change. They wanted to get the ship as far from shore as possible before any budgetary or policy storms could threaten it.

Fogg's greatest difficulty in getting under way was caused by the same ordnance officers who most wanted the Station. These officers, with added stimulation from the CalTech scientists, had opened wide the flood gates, virtually inundating the system with an onrush of new facility proposals. At the same time, they were not able to provide the precise technical data and specifications that Fogg felt were needed for effective planning. This was ameliorated somewhat by Burroughs working closely with the construction staff in preparing Station layouts.

Another factor that helped to resolve the problem was the constant attention given to establishing realistic priorities. Captain Byrnes, who appointed himself the *ex-officio* spokesman for Blandy on NOTS-related matters, was the watchdog for priorities. Speaking for the Chief of the Bureau of Ordnance, Byrnes established what work would go forward and what would be delayed. This authoritarian role did not enhance his popularity with NOTS officers, but it did create a semblance of order out of chaos. Most important, Byrnes put the full force of his position behind whatever had the top priority. If, for example, Burroughs could justify a proposed addition, Byrnes, with magnificent confidence and dignified bearing, would tirelessly roll over any who dared to oppose him in the Bureau.

Insight into the decisiveness and forcefulness of Byrnes even on matters of detail can be had by eavesdropping these decades later on a telephone conversation of December 28, 1943. (Byrnes' practice of having telephone conversations with field stations recorded and transcribed was in itself a hint as to his thoroughness.)

BURROWS [sic]: I had planned on flying either today or tomorrow and according to Saunders he said you wanted me to stay out here until this thing was pretty well jelled.

BYRNES: No, that isn't what I said. I told him that this Bureau and the Bureau of Yards and Docks were anxious to get ahead with the construction of the permanent facilities as fast as possible and was apprehensive that we might get part way through the project and find ourselves embarrassed with the lack of funds so we wanted you to stay out there long enough to give Captain Fogg adequate information so that he could submit to the Bureaus for review a tentative layout, a general layout of all the areas.

BURROWS: A complete job.

BYRNES: No. A general layout. That simply means showing the size of the buildings in the various areas and where you are going to put them as

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we have got to plan the water supply to them and the power and heating and all that kind of thing because all those factors enter into the cost of development. . . .

On January 12, three days before Fogg was to be relieved of his "second hat" duties as Acting Officer in Charge of Construction, he completed the site plans and schematic drawings of all the buildings and facilities then contemplated (see list in Appendix A).

When Captain Fogg signed the letter transmitting the NOTS site plans he should have felt the satisfaction of a runner having successfully finished the starting lap in a relay race. Others would take the baton and run, but he had given them a critical lead. Many temporary facilities were close to completion. A plan for the permanent facilities was in hand.

In mid-January, 1944, the baton of master building passed to Captain Oscar A. Sandquist, Civil Engineer Corps. This officer entered the construction race on the run and never let up until one year and approximately 1,000 buildings later.

Sandquist's specialized Navy experience went back to World War I, when as a lieutenant, he was Officer in Charge of Construction of two large stations in succession. Between wars he was a successful contractor. Recalled to duty in 1940, he led the task of constructing a large naval airfield at Norfolk, Virginia. Sandquist shared with Burroughs similar personal assets—calmness, perseverance, and geniality. His professional assets included two equally strong suits. As a former contractor, he knew contractors and how to work with them; as a naval officer, he knew the Navy's needs and the Navy's ways of getting things done.

When Sandquist arrived he was responding, as he later recalled, to "very secret orders." These orders had brought him and his wife and daughter to an inhospitable desert, for when they arrived at Inyokern they could find no quarters for the night and had to drive on to Trona. "It was very impressive, all this vacant, desert country! We thought we were going down into Hades or something, all those signs 'Don't Drink—Poison Water'."²⁴

The next morning, January 15, Sandquist met Captain Burroughs and Chief Snyder at the NOTS site. The three of them immediately went into a prolonged conference on the status of the work in progress and the proposed construction. The next day Sandquist inspected the plans and work sites and on the third day he flew to San Diego with Snyder to meet with Captain Fogg. In three days, Sandquist absorbed a complete background—including concepts, plans, and layouts for hundreds of facilities. He was ready for action.

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Captain Oscar A. Sandquist Officer in Charge of Construction during major thrust of Station's construction in 1944.

He immediately saw the problems incurred by continuing to have the Station headquarters at the Inyokern airfield while the main construction job and the heart of the weapons work would be centered increasingly at China Lake, some 10 miles to the east. Burroughs agreed, and on January 17, while Sandquist was still at San Diego in conference with Fogg, a call was put through to Washington requesting that the 20 Quonset huts and Stran Steel buildings intended for the Inyokern airfield be constructed at the China Lake site instead. This would make it possible for Burroughs to set up headquarters there immediately rather than wait for the permanent headquarters building. It would also make it possible for Sandquist to have office space nearby. Bureau of Ordnance approval voiced by Byrnes was granted within minutes. Thus through a simple phone call, China Lake, rather than Inyokern, was assured of becoming the headquarters of what would later become the Navy's largest weapon research, development, and test center.

Another Sandquist decision, made in the first few days, was to continue the contract with Julian T. Stafford for the design of the permanent facilities. This design contract was later extended to bring in a combination of three highly recommended architects and engineers—Stafford, J. H. Davies, and H. L. Gogerty. Subsequent events showed this to be a wise move. The design work, although subject to more than the normal amount of changes, maintained a close but important lead over construction so that the latter was never held up substantially for lack of plans.

Sandquist had the ability to visualize broad plans and keep a long-range construction job moving. At the same time he knew how to meet immediate problems and how to concentrate on items that he and Burroughs felt were critical.

It is interesting to note an example of the kind of permanent facilities that were given precedence by Sandquist and Burroughs. On his fourth day, Sandquist began plans to contract for the construction of the Bachelor Officers' Quarters and the Officers' Mess Hall and Recreation Building. The structure later became known as the Commissioned Officers' Mess (Open) and serves as such to this day. In the realities of opening up a desert frontier, precedence over office, laboratory, and machine shop went to bed, bar, and mess.

In the facilities planning, Sandquist experienced the same difficulty Fogg had had in obtaining information on what was to be done and at what magnitude for the permanent research and development laboratories. The blue-sky discourses of the Ordnance

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officers on the value of exploring the unknown and applying the latest technology to weapons problems were of little help without accompanying data leading to specific sizes and requirements. For specifics, Sandquist would have to wait; not because the problems were being ignored, but because no single individual or group had the answers. The Navy was moving into a new arena. The question of what kind of research and development laboratory was needed required projections into the needs of the Navy through and beyond the war predictions of what aspects of science and technology would be most applicable to future weapons. The answer also depended on the collection of information on the past experiences of existing laboratories with similar or related missions.

EARLY LABORATORY PLANNING

Laboratory planning had in fact been a matter of concern of Burroughs from the time it became clear that the Navy would be accepting his proposal for a new station. And when the opportunity to do something about the problem appeared, he seized that opportunity.

Again in the charmed life of early NOTS, the opportunity came at the proper moment and with a lead player ideally suited for the role: Lieutenant Commander (later Captain) James A. Duncan, a former student of Dr. Albert A. Michelson, a Navy reservist, an instructor in physics at the United States Naval Academy, and a man of broad vision and perseverance.

For Duncan, the episode began at the start of his Christmas vacation from the Academy in 1943, which he took as an opportunity to see if there was some research assignment that would be more directly related to the war than teaching physics. For Burroughs, the episode occurred as he was preparing to leave his Washington office in the Bureau of Ordnance for his desert assignment.

In an unusual way to start a Christmas vacation, Duncan presented a letter of introduction to the head of the Bureau's Research Division, Captain Carroll Tyler. When he told Tyler his objective was to get into research work for the Navy, the Captain's response, as later recalled by Duncan, was as follows:

He suggested that I walk down one side of the hallway and back on the other and stick my nose in every door that I came to and tell them that I was looking for a job for a physicist. When I went all the way around and

got back to Reb, I found Captain Burroughs, and he was interested in somebody to help him build a laboratory. He thought maybe I might be able to help a little. So he agreed to put a request for my transfer from the Naval Academy to the Bureau of Ordnance.²⁵

By early February, Duncan received orders designating him "Laboratory Officer, Naval Ordnance Test Station, Inyokern, California" and calling for him to proceed to NOTS. But as he was about to drive out of the gate at Annapolis he received a telephone call saying that he was to go to the Naval Proving Ground at Dahlgren, Virginia, first in order to make a brief study of weapons experimental work there. This was the beginning of a circuitous two-month road to Inyokern.

Back at the Bureau of Ordnance following his brief visit to Dahlgren, Duncan reported to Captain Byrnes, the Bureau's administrative head for ordnance stations, who told him that the Bureau of Yards and Docks had a committee that was going to visit a number of laboratories* to study the facilities. Duncan was to accompany them as the Bureau of Ordnance representative. As he recalled:

I had very interesting instructions from Captain Byrnes. His instructions were, "You are to go with this committee and see that the Bureau of Yards and Docks gives the Bureau of Ordnance what they want." Nothing was said about what the Bureau wanted!

After we started the trip I asked the BuY&D people what the Bureau of Ordnance had told them about what they wanted. And the answer they gave me was...they wanted a laboratory in which the Bureau of Ordnance could later do anything that it decided it wanted to do. This really led to a pretty definite picture of what the organization had to be like and what the laboratory had to be like.²⁶

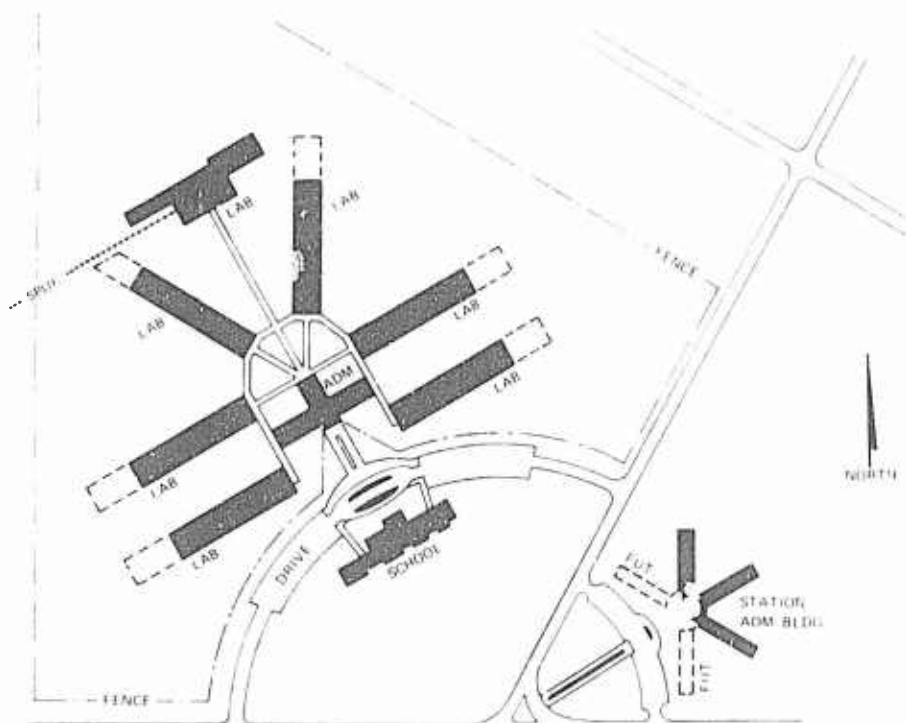
This first trip presaged what was to become a veritable traveling career for the NOTS Laboratory Officer aimed at planning, equipping, and finally recruiting for the laboratory. In two years Duncan would make 26 round trips from Inyokern to Washington, D.C., alone. In fact he spent very little time actually at NOTS. He operated principally out of the Bureau of Ordnance, physically occupying the very same desk that Captain Burroughs had used before he became the Commanding Officer of NOTS. But this first tour of the nation's

* The facilities visited included the Mellon Institute, Pittsburgh; the Bell Laboratories, Murray Hill Division; the Radio Corporation of America, Princeton, New Jersey; Battelle Memorial Laboratories, Columbus, Ohio; Armour Research Foundation, Chicago; Gulf Research, Pittsburgh; the Bureau of Mines, Bruceton, Pennsylvania; Armament and Projectile Laboratory, Dahlgren; the Naval Ordnance Laboratory (then located at the Naval Gun Factory in Washington); Wright Field, Dayton, Ohio; and a plastics laboratory at Silver Spring, Maryland.

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principal laboratories was all-important; it helped answer the question, "What kind of laboratory or laboratories does the Bureau of Ordnance want?"

The answer did not come as soon as Sandquist and the other on-site builders had desired, but as it subsequently developed, had the search not started when it did, the chances are that what is now Michelson Laboratory would either not have been built at the desert site or it would have been built on a smaller scale. In either case NOTS as a desert facility probably would have remained a test station and would not in future years have become a principal research and development center for the Navy.



Proposed wheel-spoke layout for the main research and development laboratory, 1944.

CAPTAIN AT THE HELM

Burroughs received Duncan's periodic reports on the laboratory as tonic for the soul. He wanted the NOTS laboratory to be "the finest laboratory of its kind in the world." He visualized it as the

heart of the total research, development, test and evaluation complex, which he characterized as being "an American Peenemünde." Duncan's reports confirmed that the dream was attainable.

Despite Burroughs' personal desires to be more involved in the details of laboratory planning, he recognized that his own role in those early months had to be focused on more tangible and immediate problems—but in a way that would also ensure the future of the laboratory operations.

In pulling together all the facets of Station building into meaningful work plans and schedules, Burroughs' greatest need was for a strong executive officer in whom he could have confidence to serve as his *alter ego*. But this he did not have in those first months at Inyokern.

It is not clear when and why the rift began between Burroughs and his Acting Executive Officer, Lieutenant Commander Acree, but it was sometime within the first two months of Burroughs' arrival. For whatever reasons, the effect was that Burroughs had no confidence in his assigned second. As a consequence he kept for himself tasks that normally would have been transferred to his "Exec."

Each succeeding pressure, whether from immediate problems or long term concerns for the future, appeared, at least to the casual observer, to have little effect on the seemingly unexcitable captain. The same warm smile and intensely personal concern were there for all with whom he dealt. His natural courtesy never left him even in the midst of administrative crisis. In the most tense circumstances he took the time to extend the wide gestures of graciousness that showed he cared for all who crossed his path, whether fellow officers of higher or lower rank, enlisted men and women, scientists, bulldozer operators, messboys, or whoever. His intense personal interest in people made him want to know about the family of his new yeoman. When he saw someone in need of a ride, he would halt the jeep and with a big smile, bid them to hop aboard. These were little things, but they revealed the total man.

Although the natural geniality of the man masked his reaction to stress, those who knew him best could tell when the pressure was building inwardly—and so could he. Fortunately, he knew how to obtain relief. Word would be sent to his "plane captain" Bill Camp to "rev-up" an F6F-3 (Hellcat) or some other fighter if available. More often than not, Burroughs would tie the flight in with other business, such as discussions with the cattlemen at Lone Pine, but in any

event, alone at the controls of the plane in that realm of peacefulness reserved for pilots, he found relief from the earthbound pressures. There in the desert sky he was able to gain the broader perspective of what he was doing at NOTS. There above it all, the multitude of little problems became manageable parts of the one big problem: TIME.

But that is what the battle for ordnance development was all about. CalTech and the NOTS command would have to do what they could to make up for the years that had been lost before the war because the armed forces had not recognized the potential of rockets, particularly for aircraft. Although remarkable technological progress had been made with slender defense budgets in many fields, rocketry was not one of them. Burroughs had been in the Bureau of Ordnance in those days when naval budgets had been pared to the quick. He had been among the few who had sought research funds specifically for aviation ordnance. Then there was plenty of time, but little money. Now he had the reverse.

But in the new fight he was not alone. The Bureau of Ordnance was behind him, fully awake to the needs of aviation and capable of pouring millions of dollars into any reasonable method of foreshortening the war and strengthening the role of ordnance research and development for the future.

It was a powerful Bureau and it recognized its responsibilities for its new Station. At that time, as contrasted to later history, its lines of authority and accountability were not ambiguous. They were direct and effective. Burroughs was aware of various inter-Bureau conflicts, but when it came to funds or approvals for NOTS, he knew he had a concerned parent Bureau to go to and one that would deliver without having to go through a confusing administrative labyrinth. If it took money called out for naval vessels to do a needed job in weapon development, it would be done. That was the policy and the strength of the wartime Bureau.

Burroughs also felt the indirect support of an operating Fleet that was becoming increasingly aware of the importance of having technologically advanced weapons. And in his leadership in building NOTS, he had a ready-built scientific staff. It was true that these CalTech scientists worked "with" rather than "for" him, but under the circumstances of wartime motivations the effect was the same, if not better. The CalTech team included members of the National Academy of Sciences, men of world-wide reputation in science, and scientists who were not humbled by bureaucracy nor timid about

seeing whoever, or doing whatever was needed to aid a wartime project (see Appendix B).²⁷

But for every takeoff there had to be a coming back to earth. For Burroughs it was a return with thoughts and plans reordered and enthusiasm revitalized.

Perhaps the new Skipper had just returned from a flight when he called a meeting of all his officers during those early months. Among the ten mustered was young Lieutenant (jg.) A. Lincoln Pittinger who had recently reported aboard. The gist of Burroughs' message to his staff made a profound impression on the young officer; so much so that he was able to recall the message after nearly thirty years:

I think we still have a long war ahead of us. We're going to have to blast out the Japs from every little island in the Pacific. Then we're going to have to invade the main Japanese islands and fight a foot by foot battle until we capture Hirohito. This may take another five years.

Now this Station is going to be an important factor in beating the Japs, and the work is going to be done mostly by civilians with you men backing them up. I don't like this situation any better than you do, but we just don't have Navy personnel to do the job—we have to use the brains of these professors to dream up solutions to our military problems.

It is the job of all of us to see that these civilians get everything they need to do their jobs. One thing I want to say—you're all going to be asked to plan programs and think out answers to problems you've never heard of before—and for God's sake, think big!²⁸

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NWC identification numbers are those under which copies of documents are filed in the Technical Information Department, Naval Weapons Center. The following abbreviations are used to identify record collections where documents were found:

LTET	Papers of L. T. E. Thompson, Scarsdale, New York
FRCB	Naval Weapons Center records stored at Federal Records Center, Bell, California
FRCM	Naval Weapons Center records stored at Federal Records Center, Mechanicsburg, Pennsylvania
OA	Operational Archives, Naval History Division, Washington, D.C.
NA	National Archives, Washington, D.C.

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DESERT SHIP UNDER WAY

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2

Mojave Metamorphosis

Just as rocketry had been a sleeping giant among U.S. weapon programs, the Indian Wells Valley in the northwestern Mojave Desert was another kind of slumbering giant; the arousing of one brought a startling awakening to the other. The economic, social, and cultural impact of the Navy on a remote and undeveloped desert area is a historically significant story in its own right. However, the long-term significance of the desert transformation to national defense was not foreseen by many except some founders like Blandy, Burroughs, and Byrnes. They knew that with the end of the war it would take more than a call to duty to bring the quality of scientific and engineering talent to the desert that would be necessary to make NOTS into the kind of permanent weapon research and development center they envisioned. They knew the success of the Inyokern experiment would depend not only on having superior laboratories and nearby well-instrumented ranges but also in having a reasonable social and cultural environment. As men of foresight they could see beyond the frustrations of sandstorms, miles of open ditches, and overpopulated shanty towns to a new kind of life in the upper Mojave; an environment that would assure the success of the experiment at Inyokern.

Unique circumstances brought NOTS into being at a time when military rockets reached a peak demand, when the CalTech development team had reached its zenith, when training in the use of rockets had become critical, and when the postwar planning for Navy research and development in weaponry was beginning to take form. Under these unusual circumstances the young Station was able within

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its first year of existence to have an impact on weapons going into the war and upon the weapon planning in Washington. Besides these effects linked to the Station's mission, the building of the Station triggered a major transformation of the upper Mojave Desert. To appreciate the magnitude of this change it is necessary to go back to the beginnings of man's known history in the area and to recognize that through the aeons preceding the Navy's arrival, Indian Wells Valley was, with few exceptions, a place to go through and not to.

SLUMBERING DESERT STIRS

Centuries earlier, before the coming of the white man, tribes of migrant Indians traditionally used the water holes at the base of the southern Sierra Nevada during their peripatetic pursuit of game. It was for these early people and their wells that the Valley was named. The Indian wells were a welcome stop for all who subsequently ventured into an otherwise inhospitable desert valley: trappers, adventurers, missionary priests, pathfinders, trailblazers, and immigrant settlers.

The evidence is not conclusive, but it appears that the first Caucasians to pass through part of Indian Wells Valley were early trappers seeking a way through the Sierra Nevada, the majestic mountain range marking the western boundary of the Valley. Unfortunately, Jedediah Smith, trapper and explorer extraordinary, was more interested in furs and adventure than in recording which trails he took; hence, clear confirmation is lacking as to whether his excursions along the east face of the Sierra brought him through the Valley in 1825. It is quite likely that the pathfinding of another early trapper, Peter Ogden of the Hudson Bay Company, took him through the Valley in 1829. More certain is the trip by Joseph Walker in 1834 in which he led a party through the Valley and through the famous pass in the Sierra that now bears his name.

To none was the water more vital than to the fragmented groups of the ill-fated 49'ers who sought a shortcut to the California goldfields and had to abandon their wagons in Death Valley. The heroes of this episode were William Manly and John Rogers, who, during the rescue of the Bennett and Arcane families, thrice traversed the Indian Wells Valley on their way back and forth between Death Valley and the San Fernando Valley nearly 200 miles away. The first trip, on foot, was to find a way out. On their return trip, their

horses weakened and succumbed to the torturous environment of the Indian Wells Valley, leaving the adventurers with only a little one-eyed mule for packing purposes. The final crossing was to lead the way out for the Death Valley families with two of their small, sick children hanging on opposite sides of the family ox, "Old Crump," in slings made from their fathers' shirts. Needless to say, these travelers were not impressed with the Indian Wells Valley other than for its providential water supply.

John Goller, one of the 49'ers who made the Death Valley escape, supposedly stumbled upon a canyon filled with placer gold and brought back some nuggets to substantiate his find. There was a delayed reaction of some years, but as the story of "Goller's gold" spread, it spurred a whole legion of prospectors to seek their fortunes in the Indian Wells Valley and its environs. For more than half a century, on through the time of the Navy's arrival, prospecting and mining played an important role in the Valley's chronicles, particularly in times of economic panic when the jobless would seek their dream bonanza on the desert.

The era characterized by "one-burro-and-a-blanket" prospectors soon passed, and in the 1870s, the Valley began to witness an upsurge of trade represented by the regular passing of ore wagons from the Cerro Gordo silver mine along well-defined wagon roads. It also saw the emergence of a freight and passenger service based at Coyote Holes just south of the Indian wells. The stage coaches, in particular, attracted the attention of frontier bandits like Tiburcio Vasquez. His former hideout in a large outcropping of rocks in the Valley is called "Robber's Roost" to this day.

During the first decade of the twentieth century, the inhabitants of the Valley changed from itinerant wanderers to a few permanent settlers. The Desert Entry Act brought in a few homesteading families, and construction of the Los Angeles aqueduct (begun in 1908) resulted in a further population increase. This project, to tap the waters of Owens Lake in an adjoining valley to the north, realized an influx of laborers, some accompanied by their families. After the aqueduct was built (in 1914), a few of these families remained to homestead and seek subsistence from fruit growing and limited diversified farming. Two small clusters of homes were called out as the towns of Leliter, a former aqueduct supply station, and Brown, which was primarily noted for George Brown's hotel.

During the aqueduct construction period, the Southern Pacific Railroad established a siding for building supplies at a

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“dot-on-the-map” hamlet, close to the boundaries of Inyo and Kern Counties; it was first named Magnolia, but in 1913 the name was changed to Inyokern.

For the most part the fortunes of the first hardy settlers in the Indian Wells Valley were never realized. The desert aridity and savage summer climate proved to be too extreme for profitable farming, and by the 1920s farms were abandoned, eventually reverting to a natural landscape of creosote scrub bushes, cacti, and tumbleweeds. Only a handful of people were left to their near-hopeless task of trying to tame the Mojave Desert.

The Valley’s resumed slumber at the beginning of the 1930s might well have remained indefinitely undisturbed. However, while it slept, the outside world was softly making significant encroachments: Highways 6 and 395 running through the Valley were paved; an 88,000-volt power line was installed parallel to the aqueduct; and the



Desert site of NOTS at the time of one of the first California Institute of Technology’s reconnaissance tours on October 17, 1943.

Inter-State Telegraph Company strung a telephone trunk line alongside the railroad steel, connecting the tiny General Store at Inyokern with Los Angeles. Most significant to our story, an airstrip with 4,500-foot paved runways was built at Inyokern under the National Recovery Act. It was intended to be an auxiliary landing field for Kern County; however, it was an airfield virtually without aircraft.

At the onset of World War II, ironically—and without any predetermined plan—the Indian Wells Valley, with about a hundred permanent residents, had its own water supply, railroad, paved highways, electricity, telephone, and a serviceable, albeit modest, airstrip!

It was into this scene that the Navy had moved in late 1943.

Before looking at the impact of the move on the small communities that existed in the Valley, it will be helpful to examine the first population buildup, that of the military in the winter of 1943-44 at the Inyokern airstrip.

LIFE AT THE AIRSTRIP

As the pattern of Quonset huts grew, there was an influx of naval officers and men to fill them. Joining them were a few scientists, engineers, and technicians of CalTech who for the most part came and left with each series of tests. But it was the Navy personnel who set the cultural tone. And it was the isolated, untamed desert that gave life a unique coloring. As one early unpublished history understated the problem, “The Mojave Desert can in no way be considered as conducive to morale.”¹

Even before he arrived on the desert, Burroughs knew that there would be serious difficulties in trying to achieve a morale level somewhere between bearable and good in an undeveloped desert lacking in social and recreational resources.

But just as fate had helped Burroughs find an officer-physicist (James Duncan) when the problem of planning the research laboratory first came up, so too it seems did he have some “outside” assistance in finding someone ideally suited to the job of morale building just as the problem was coming into focus.

Shortly after Burroughs learned he was to assume command of NOTS, he had a flight layover at the Naval Air Facility, El Centro, California. By chance he came in contact with Chief Warrant Officer John S. (“Baldy”) Ewing, an outgoing, zestful individual whose

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avocation was having fun for himself and whose vocation was to make fun for others. Up until his chance meeting with Burroughs, he enjoyed a pleasant job as the head of entertainment for the Eleventh Naval District. On this occasion he had taken a show to El Centro, where he met Burroughs. After the show they shared some drinks—to quote Ewing, “It was hot country!”²

Burroughs, with the congeniality he would later use in recruiting scientists, told the ebullient recreation officer that he was going to be the Commanding Officer of a new Station at Inyokern and asked if Ewing would like to go there. Ewing later recalled his reaction, “He was a Captain and I was a way down the line . . . so I said, ‘Sure.’ I thought it would be forgotten. He doesn’t forget! Three or four days later I was walking across the compound down at the 11th Naval District and . . . the Personnel Officer said, ‘Hey, . . . where did you know Ev Burroughs?’ I said, ‘Who?’ He said, ‘Ev Burroughs.’ I said, ‘You’ve got me wrong, I don’t know him.’ ‘Oh yes, he’s put in for you. You’re going to Inyokern.’ Then I thought it must be India someplace.”³

Ewing reported in on December 31, 1943, to Lieutenant Commander David E. Saunders, Acting Officer in Charge of the Inyokern airfield, as Burroughs was in Washington at the time. Saunders was delighted to have the recreation-oriented chief warrant officer aboard. Every military unit needs at least one resourceful, social-minded scrounger as was recognized by Saunders, and later Burroughs, as qualities of Ewing. Saunders first asked Ewing to start a ship’s service store, which he did, but not without difficulties. He called the Naval Air Station in San Diego and arranged for them to send a lot of items. When the shipment arrived, he found that most of it was intended for the woman consumer. In recollecting his surprise he said, “And you could look in any direction up here 100 miles and never see a woman.” But financial catastrophe for the new ship’s service was averted by the fortuitous arrival of some Navajo Indian laborers who eagerly purchased the hitherto unusable items of feminine adornment.

Saunders then introduced his next objective for NOTS by stating to Ewing, “I understand Captain Burroughs likes to drink once in a while so we’ve got to start an Officers’ Club. I’ll put in \$25, and you’ll put in \$25. Ensign Cody will put in \$25, and I’m sure the Captain will put in \$25.” It is uncertain whether this proposal ever realized cash in hand, but in any event a decision was made by Saunders that mail delivery could be suspended for a couple of days

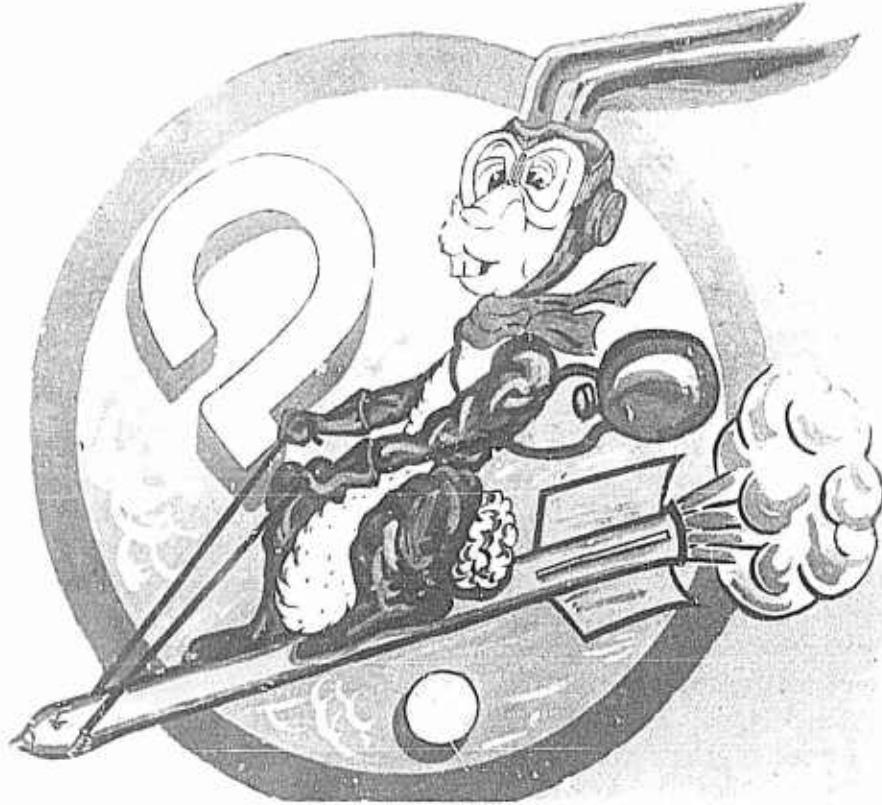
so that Ewing could take the mail truck to San Diego to obtain Officers' Club supplies. Ewing reports, "I came back with a pickup truck of liquor, and in those days you took what you could get and the majority of it was Three Feathers. . . . I hauled it in, but when I got back I had no place to put it, and that's when I got really acquainted with Emory Ellis [supervisor in charge of CalTech personnel at NOTS]. Dave said 'Go over and see Emory. He'll help you out.' So they had a little wired-off section of one of those Quonset huts and in that were confidential papers and everything, but they weren't valuable; the liquor was valuable. So Emory said, 'Well let's put it in here.' So I put my liquor in there and fortunately we didn't have any thieves in that day on the base."

With the stock of Three Feathers stored with the confidential papers, the future of the NOTS Officers' Club was assured. A Quonset hut served as the first clubhouse, and two Filipino sailors were assigned to the duties of mess attendants. They not only acted as bartenders, but also served sandwiches and hard-boiled eggs. For a while ham sandwiches were served, but their availability as preferred fare caused officers to forsake the general mess; so their sale was restricted to after-dinner hours. A final touch was given to the Officers' Club after Ewing spoke to Sheriff J. E. ("Johnny") Loustalot of Kern County about the recreational needs in the desert outpost; three or four days later the sheriff delivered five slot machines for the club's use. (Slot machines were legal in Kern County at that time, although delivery by an officer of the law was a service obviously over and above the call of duty.)

Some twenty-five years later, in recalling some of the lighthearted moments in otherwise grim days, Burroughs still retained his warm regard for Ewing: "He's a scrounger; he's an organizer; he's the greatest guy to get things going and particularly to keep everybody laughing all day through."⁴

Symbolic of the spirit of early NOTS at Inyokern was the special NOTS insignia—a cross-eyed jackrabbit riding on a rocket. The first version of this emblem was designed by personnel of AODU-1 while they were at San Diego and it originally contained the letters "AODU." For the early use at Inyokern these letters were replaced with a large question mark. This insignia appeared on a wide range of objects from aircraft and flight jackets to Officers' Club decorations.⁵ Appropriately, like the perplexed desert rabbit on the rocket, its creators were aware of their unique situation but were not particularly enjoying the ride.

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Early NOIS insignia.

BOOM TOWN OF INYOKERN

Essentially overnight, Inyokern was on its way to becoming the new boom town of the Mojave Desert. As such, it compared well with the lustiest of the Old West mining towns with a share of shady characters, gunplay, high spending, saloons, gambling, fist fights, and raucous entertainment.

Despite the influx of twentieth century dwellers, the town's setting and its cast of characters retained an old frontier flavor. The wide unpaved main street with a water tower in the middle was the center of action. Spreading out from the center was a miscellany of trailers, tar paper shacks, and adobe huts. Buildings of indescribable decrepitude were pressed into service for lodging. There was allegedly but one public eating place, boasting a lunch counter with six seats. An article in *Pageant* magazine describes its operation with some

journalistic enhancement: "With 6,000 men trying to get in, spirited bidding arose for available food; blue-plate specials are said to have cost up to \$40. Other lunch counters soon appeared and made similar profits..."⁶ However, there is some doubt as to the veracity of *Pageant's* reporting. A former naval officer stationed at NOTS in the early days commented, "None of this is true. The Navy kept out profiteers."⁷

The character of booming Inyokern was determined not only by its staggering number of people but also by the roughneck nature of a large percentage of new citizens. The building of NOTS had no priority when it came to the national labor market. Other major war construction projects had started much earlier. Consequently, the labor pickings were none too good when NOTS got under way. Moreover, the desert environment and its remoteness from normal labor markets made recruiting extremely difficult for the contractors building the Station for the Navy. It was not a matter of selecting people but of hiring whoever would come.

There was no town government, and it was more than the county officials, with their headquarters at Bakersfield, 130 miles away, could do to preserve any semblance of law and order. The impossible task of administering justice fell upon Ardis Manley Walker, the justice of the first judicial township of the County of Kern, which included the Indian Wells Valley. He recently recalled:

...I can remember suddenly being faced with the problem of serving a community of several thousand people when previously I could count the total number...by tens or twenties and in my total township perhaps by the hundreds.⁸

The Navy tried to aid the county's law-enforcement efforts, but generally it was impossible to curb the boom-town spirit. In one epic fight 47 persons were hospitalized and there would have been more had not the Navy sent in truckloads of Shore Patrol. Robberies ranged the full gamut from simple back-alley heists to the robbery of the mail truck by masked highwaymen quartered in Inyokern.

Another element of the Old West was added with the arrival of several hundred Navajo Indians who had been recruited from their New Mexico reservation to build the railroad spur for the Station. Their colorful heritage added a fascinating blend to the melting pot of many different cultures that were suddenly being mingled at Inyokern: cultures that were rooted in the old world as well as the new. Whatever bewilderment these first Americans may have previously felt about the ways of the white man, these feelings were probably confirmed in the frontier madness of Inyokern.

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The opposite was also true. The Caucasians did not understand the customs and sociology of the Navajos. For example, one early timer arriving at NOTS when the temperature was well over 100 degrees was amazed to see the Indians wearing blankets. Apparently, he was unaware of the fact that the Navajos were a desert people, and as such could thrive in an environment in which most Caucasians could barely survive.

There is no doubt that the lack of sociological understanding was equally shared by Caucasian and Indian. To the Navajos, the aspects of labor unionism must have seemed totally arcane, as did the technology of twentieth century facility construction. Unfortunately, there was a language barrier that precluded widespread communication. One early timer tended to oversimplify the difficulties of the Navajos. He said in retrospect: "Most of the troubles with [them] were solved when it was found that what they really wanted was one of their traditional sweat baths—sort of sauna . . . [the Navy] agreed to build one for them, and after that there were no more complaints."⁹

Little is recorded about the long-haired, blanket-clad men who played a short but significant role in the building of NOTS. When their job was done, Mark Sodapop, Fatty Charlie, Black Goat, Red House, and their tribal brethren quietly returned to their reservation, probably unaware of the import and impact of their sojourn in the Indian Wells Valley.

As with most boom towns, the isolated desert community had few traditional recreational resources for the thousands of workers (some with families) who lived there. Piano playing and gambling enlivened the action at the local saloons. For a price, a person could get a 50-mile-round-trip ride in a battered old touring car, marked "Taxi," to the mining town of Red Mountain, then notorious for its ladies of the evening. But the principal pastime at Inyokern was to play the role of spectator in watching and reflecting upon the main street activity of the last of the great frontier boom towns of the Mojave Desert.

MIRACLE CITY

Eight miles east of Inyokern, a miniscule farming community called Ridgecrest—with neither a ridge nor a crest—was ill prepared as

Inyokern had been for a sudden Navy onslaught. But the assault on the quiet life of the desert hamlet was on its way with the beginning of the first construction at the main site of NOTS at China Lake. It was then clear that a Navy village of undetermined size would be built adjacent to Ridgecrest, and it could be surmised that the on-base village could not take care of all the community needs. With this observation, the population center of Indian Wells Valley began to make its shift from Inyokern to Ridgecrest.

In November 1943, Ridgecrest had 15 homes and 96 residents.¹⁰ In contrast, at the end of the war in August 1945, it would have over 75 licensed business establishments and would become the trade center for approximately 500 permanent residents in the Valley.

But not even this rapid growth trend could truly presage the community's subsequent growth. Today, with a population of more than 14,000, the City of Ridgecrest closely competes with Delano, California, for the distinction of being the second largest city in Kern County. The city's wide range of modern facilities—shopping centers, banks, colleges, and county buildings—all evidence the dynamic nature of its continuing growth.

The first permanent settlers in Ridgecrest were George Robertson and his family, who, in 1912, homesteaded land on which much of downtown Ridgecrest now stands. A year later the Grant Bowman family also filed a homestead claim on 160 acres that comprise the southern area of the present city.

After George Robertson's death, his homestead passed through several ownerships including that of Robert Crum, who, with his brother Jim and cousin Wilbur Crum, operated a dairy on it in the early 1930s. The settlement of six or eight dwellings was made up largely of various Crums and became unofficially known as "Crumville" and the natural target of jokesters.

When Robert Crum left the area in 1936, he sold his lands and dairy to Joe Fox, who had come to the area two years before to set up and operate a diesel pump for irrigation on Bowman's ranch. Fox was a resourceful man as indicated by the hand digging of his first well through more than 60 feet of sand and caliche. After taking over the Crum properties he soon had more than 40 acres of alfalfa and 7,000 chickens.

In 1939 William Bentham brought his family to the area and erected the town's first store and gas station on property bought from Fox, at the site of what is now the intersection of the city's main streets: China Lake and Ridgecrest Boulevards.

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In 1940 with the population approaching 100, the leading citizens gathered at Bentham's store to discuss a new name for "Crumville." They submitted "Sierra View" to the Post Office Department, at the same time requesting a post office for the town. The postal authorities agreed to establish a post office but rejected the suggested name because there were already too many "Sierras" in the State of California. They asked for another name proposal. Residents posted their suggestions on the bulletin board in Bentham's store. A visitor of Bentham's who was not a resident, and therefore not strictly eligible to participate, had pleasant memories of Ridgecrest, Missouri, and wrote his name on the board. By selection day, there were numerous candidate names, but many of them were uncomplimentary—for example, "Rattlesnake Gulch." By a single vote "Ridgecrest" won over "Gilmore," which was the proprietary name of the brand of gasoline sold by Bentham. The name was accepted, and Bill Bentham became the town's first postmaster with the post office in a corner of his store.

In 1944, when the Navy started to construct a station and a community next door, the town of Ridgecrest would promptly begin to grow. The commercial and home growth would center in the area of the Fox ranch largely because a ready water supply existed, and also because Fox was interested in helping a town develop.

Construction workers were lodged in every habitable house and shack in the area. To meet the huge demand for housing, new structures built from a hodgepodge of materials went up overnight. Building supplies were at a premium; so anything that could be located was used. Corrugated steel roofing and packing crates were common materials; so too, was lumber stolen by night from stacks of supplies designated for Station construction. It was a war economy and there was a nationwide shortage of materials for "nonessential" construction. Local sources for purchasing new building supplies were virtually nonexistent. Also nonexistent was any significant long-term financing for homes or businesses. But then, who besides a few officers in the Navy and a rare desert philosopher like Joe Fox was thinking of anything permanent for Indian Wells Valley?

The prevailing boom-town attitude profoundly affected the quality of the early homes and stores. Few were the optimists who expected Ridgecrest to survive the war. Future planning was seldom attempted; and, as reported in the Ridgecrest *Times Herald*, "The town grew just as it pleased—in all directions."¹

Although with manifest deficiencies, an instant town miraculously

emerged from the fields of alfalfa and creosote bushes. It was with some truth that buoyant promoters referred to it as the "Miracle City" and called the road between the two main shopping districts the "Miracle Mile." But the true miracle was yet to come, Ridgecrest survived its tumultuous unplanned genesis.

NAVY-BUILT COMMUNITY

The planning for what would later be the largest Navy-built, Navy-managed community had begun with the facilities study of November 1943, but that planning did little more than indicate that there would be a "village" adjacent to the Station headquarters in the main Station area.

On New Year's day 1944 a meeting of Bureau of Ordnance officers was convened to discuss the kind of village needed. These officers set the pattern of the thinking for years to come by recognizing that the village was "of prime importance" to the mission of the Station. Having concluded this, they urged that the houses not be temporary structures of the type available through sponsorship of the Federal Housing Administration.¹²

Although the first facilities plan called for a small on-base community of about 1,000, there was nothing firm about this figure, nor indeed, about the location. Active consideration of alternate locations continued for several months while the borders of the Station were being defined. One proposal was for the Navy to take over most of the Valley, including the Inyokern area. In this case there was the possibility of building the Navy town near the existing Inyokern airstrip. One proposal, supported by Lauritsen, was to extend the Station's southern border into the El Paso Mountains at the southern end of Indian Wells Valley taking in the area where Cerro Coso Community College now stands.¹³ This proposal was promptly vetoed by Captain Byrnes. He objected to the Station being divided by public highways. Also, he knew land acquisition would be further complicated by an increased number of private holdings to be wrested from their owners. As the person closest to the Chief of the Bureau, Byrnes prevailed in his determination not to change the location. So for all the discussion there was only one change, and that was to combine the community, the headquarters area, and the planned laboratory into one common area.

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Although the construction was started before mid-April 1944, it is convenient to think of that date as the beginning of the China Lake community. That was when Burroughs moved his headquarters to the new area, again going into a Quonset hut that served as both office and bedroom.

The naming of the Navy community as "China Lake" after the dry playa on the Station was not something done by proclamation. It just happened as part of the natural process of referring by that name to the main Station area containing the lake. The lake itself had received its name sometime in the 1870s, although the precise origin has been lost. Most probably, the dry lake was originally noted for the presence of a few Chinese workers who harvested the surface borax during their brief sojourn there.

While Burroughs' objective was to establish a balanced community, he also recognized that isolation and military traditions worked against him. It would be difficult to develop and preserve a sense of normalcy in a town owned and managed by the Navy, and characterized by the absence of a private property ownership, as well as many of the normal legal, social, and commercial institutions. One of Burroughs' strengths was a readiness to seek the advice of people with experience related to his problems. In January 1944 he flew to the Naval Ammunition Depot at Hawthorne, Nevada, which, like NOTS, was in the desert and had faced the problems of developing its own federal community.

Burroughs had a battery of questions to fire at Commander John Odonnell Richmond, the Executive Officer at the Depot: heavy-caliber questions concerning the type of housing suitable for the desert. But there were also other questions about the experience at Hawthorne in the whole range of community services—schools, banks, post office, roads, sewage, telephones, hospital, and recreation.

Burroughs was immensely impressed as Richmond readily provided insights, facts, and solutions. Beneath Burroughs' amiable casualness, a keenly perceptive and analytical brain was at work. While recording Richmond's answers to his questions, his mind was also registering impressions about Richmond personally: an ordnance postgraduate ("he knows the ordnance side of the Navy as well as the Fleet"); a medical retiree called back for wartime duty ("whatever his bronchial ailment it's OK on the desert"); approaching 50 years of age ("nine years older or not, he would work with me—he's that kind of an officer"); class of 1917 ("a World War I vintage year"); Executive Officer of an ammunition depot ("he could use a bigger challenge").

Burroughs was not one to reveal his hand in a serious game. He made no mention to Richmond that he had gathered more than ideas about the community. But as soon as Burroughs arrived back at Inyokern, he telephoned Admiral Hussey and told him how vitally important it was that he have an Executive Officer who could help carry the mounting administrative and management load. The rift between him and his Acting Executive Officer, Lieutenant Commander J. T. Acree, had become irreconcilable and he needed help. Richmond was the man who would perfectly fill the need. Burroughs stressed it was absolutely essential that he have an Executive Officer in whom he could have confidence. He made a personal, energetic, and frank plea.

Insight into the human workings of the Navy is gained from comparison between the report of this episode as reconstructed from a later interview with Burroughs and a separate one with John Richmond. The latter is quoted as follows:

I thought he just came up here to see the Station [Hawthorne] and to see what type of housing we had up there. I had no idea that I was being considered to go to China Lake at all. . . . I got a letter from Admiral Hussey who was then Chief of the Bureau. . . . I'd known him for many years and he said they were looking for an Exec. for China Lake and that he had tossed a number of names to the different department heads in the Bureau and they all came up with my name and therefore he was asking the Bureau of Personnel to order me to China Lake. I went to Captain Vossler,* who was at that time my boss, and I said, "Look Captain, I don't want to go down there, I'm perfectly comfortable here." He wrote back to the Bureau and said, "Richmond would like to stay at Hawthorne and I'd like to keep him." But the Admiral wrote back and said, "Well no, never mind, Richmond is going to China Lake, so you tell him to get packed up and go down there—period." So that was that.¹⁴

In a later interview, Rear Admiral Vossler commented about Richmond's reassignment as follows: "My father thought the sun rose and set in John Richmond and he was very reluctant to lose him. But he also realized—especially since I was here (at NOTS)—the importance of what we were trying to do to advance the state of the art, and increase the effectiveness of air weapons. . . . so he finally reluctantly agreed to let John go, which was a boon for Inyokern and a big loss for Hawthorne."¹⁵

The rapidity with which new buildings went up in China Lake was a source of pleasant amazement to most old residents of the Valley; spectacular evidence of what a nation at war could do. But at

* Captain Francis A. L. Vossler, in addition to being the Commanding Officer at NAD, Hawthorne, was also the father of a young naval aviator then serving at NOTS, Lieutenant (later Rear Admiral) Curtis F. Vossler of AOD-11.

least one old prospector, "Blue-Eyed Pete," personally complained to Burroughs about the new structures going up on the desert, "I don't like it a bit; you're spoiling my view!"¹⁶

Following Burroughs' move to the new area, there was a continuous buildup of quarters for Navy personnel and some of the CalTech employees at China Lake. As will be described in the chapter on construction, this was the period of miles of open ditches and sandstorms.

High on the list of Burroughs' social concerns for his personnel at China Lake as well as those remaining at the Inyokern airfield was that of recreation.

From the onset there was a policy to create opportunities for military personnel to get away from the area on occasion. As Burroughs informed his staff, "If you see a man sitting out in the sand looking off into the sun banging two rocks together, you'd better get him off on liberty someplace before he flips."¹⁷

It was the "Skipper's" concern for the welfare of his men that led to the development of a special recreation area for the military personnel of NOTS. This area on the south edge of the Sequoia National Forest some 30 miles away—250 acres of grazing land, trees, and a trout stream—was loaned to the Station by the Paul Gardiner family as a contribution to the war effort. Burroughs had a jeep road built to the otherwise inaccessible area, and arranged for tents, a wooden cookshack, and a small mess hall.

Camp Burroughs, as it was called, offered a special kind of diversion to those who hungered for a peaceful, natural environment. It provided an interesting change of scenery from the desert. The men were allowed to go there for their liberties on a rotational basis.

Burroughs was always on the lookout for an opportunity to augment the recreational resources of the retreat that bore his name. One of these reveals not only his regard for his command's welfare but also his initiative and ingenuity in accomplishing a goal. In this case the first step in meeting a recreational need was to requisition horses from the Army to form the "NOTS Horse Patrol."

Ostensibly, Burroughs' request to the Army Remount Officer in Los Angeles was valid. The Station was confronting a serious security problem in that building supplies and materials were being pilfered at an alarming rate. The Navy's use of horse patrols was not unprecedented; they had been used in California at the Navy bases at Port Hueneme and San Pedro.¹⁸ But in addition to the inherently bizarre idea of sailors riding Army horses in the desert, there is a

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Camp Burroughs.

gentle, lighthearted humor throughout the correspondence negotiating the equine transfer. In one letter, Lieutenant (jg.) Frank H. Habicht stated that he had "been nominated Vice President in Charge of Horses" and conveyed his thanks for the Army Field Manual on Animal Transport, which had helped the sailors understand their new charges a little better.¹⁹

The transfer was successfully concluded as noted in a letter acknowledging the happy receipt of the horses. Habicht wrote:

The horses and gear arrived in very good shape and were promptly taken care of at this end. The only exception was "Snuffy", (the black) had skinned up his left hind leg. We doctored this up immediately and so far the horse has no limp and shows no ill effects.²⁰

In the same letter, a hint is given as to the true destiny of the "patrol" horses:

Temporarily we have the horses in a pasture on the ranch where our summer camp is located, as we still have no facilities here on the desert and have not yet received the forage which we requested.

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From the onset, Snuffy, Jiggs, Buck, Devil, Sherman, Jasper, Four-F, and Lee were destined to enjoy the softest duty of their Army-Navy career. Even after the stables were completed at China Lake and the horses returned to the desert, their mission shifted from that of the "NOTS horse patrol" to recreation. But the modest cluster of stables represented only a small concession to recreation in a growing community where, for the most part, the word recreation was synonymous with leaving town for a few days in pooled transportation, the Trona Stage (bus line) or the CalTech Shuttle (a Navy bus or station wagon depending on the number of passengers).

NEED FOR ADDITIONAL LAND

The approvals for the Navy to use the original 650 square miles of desert and the Inyokern airfield for the duration of the war had started the metamorphosis of the upper Mojave Desert. That change was accelerated by the need in late 1944 to add another 362 square miles.

The problems of acquiring this land were compounded because the necessity for it could not be publicly explained. Much later it could be revealed that the addition was to support testing for a segment of the highly secret work of the Manhattan Project in the development of the atomic bomb.

Essentially, the project demanded range space for air drops of various bomb shapes to determine such critical factors as aerodynamic characteristics, fuse functioning, and ground penetration. Also, for reasons of security, safety, and minimum interference with the rocket programs, it was desired to conduct these tests on ranges removed from those being developed and used for the rockets. There was only one way to go—northward. The Station was bounded on the west by a state highway, a high-tension line, and a railroad. To the east there was a north-south military airway and the town of Trona and its associated large potash plant. To the south was another highway and the growing community of Ridgecrest. Although the logic of acquiring an additional 362 square miles to the north was clear to the government planners, it was not at all clear to the people with mining interests there. There were about 200 mining properties and more than 1,000 mining claims within the area proposed for acquisition. Of the 231,040 acres in this northern extension, 2,840 were patented lands in private ownership.²¹

A typical exchange of views is seen in correspondence between Burroughs and one of those with mining interests, Paul A. Wilbur, who had spent many years prospecting and developing his mining property in the Coso Mountains. Wilbur wrote:

Several reputable mining engineers have spent enough time there to agree with our estimate of almost limitless mineral possibilities in the district. If it were only for "the duration" and essential to the "war effort" and we were assured of adequate compensation for damage to our properties we could not object. But to be permanently debarred and for the community and Nation to lose the great natural resources bound up in those hills is quite another matter. To that program we want to enter our most forceful and determined objection! It would mean a very great financial loss to every person who has holdings in that district—many of whom are now away from the district and engaged in various phases of National service both at home and abroad. What are these people going to think when they learn that their properties have been absorbed by the Navy while they were away serving their Country?²²

Burroughs, with the highly classified Manhattan Project in mind, responded that the land was needed for "an extensive test program at the highest possible priority." With reference to the "people in service" he wrote,

In my own judgment, those people who are now engaged in various phases of national service, Army or Navy, at the fighting fronts, would willingly give up their interest in the proposed extension area in order that essential ordnance test work may be carried on expeditiously and with minimum interference. I can assure you that one weapon which has been designed in Pasadena and tested at this station is alone responsible for saving thousands of American lives. Only by means of extensive research, development, and test work are we able to keep ahead of our enemies and thus prevent the last two or three years of this war from being terrifically costly in war casualties.²³

Just as the original northern boundary of NOTS had been drawn to avoid the relatively high concentration of mining interests, so too had it been shaped to skirt around a small health spa at Coso Hot Springs. However, the Manhattan Project plus the increased range space needs of the rocket program and the emergence of a clearer concept of the Station's permanent peacetime role made it necessary to acquire the health spa property located within the proposed northward extension. Considerable objection was raised to this proposed acquisition. Mark Dailey, proprietor and manager of Coso Hot Springs, wrote to the Secretary of the Navy and to the President of the United States:

This property is being taken over by the Inyo-Kern [sic] Navy Testing Base simply as we are given to understand, an addition to the acreage used for testing purposes. This is an injustice to suffering humanity, these natural mud and natural steam baths at these Springs are considered by thousands of people who have been cured at this resort as the only means in the world of curing arthritis, neuritis, and kindred ailments.²⁴

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Dailey was sincere in his beliefs as to the curative powers of the hot springs. He and others urged that if the land had to be taken for military use, it be made into a sanatorium for the wounded of the Armed Services.

The Navy made a detailed study of the Coso Hot Springs area for appraisal purposes, including investigation into the possible medicinal properties of "the natural mud and natural steam." Opinions from medical authorities denied any such curative properties, and the Medical Officer of the Eleventh Naval District concurred in these findings. Concerning Dailey's last recommendation, the study concluded that even if the property had possibilities for the establishment of a naval hospital, "its location in the center of the present station would preclude such use."²⁵

While efforts were in progress to extend the Station's northern boundary, two other acquisitions were also sought. These were described as the "west extension" and the "east extension." The proposed west extension contained about 6,460 acres of which some 4,570 acres were patented lands in private ownership. The basic purpose of this extension was to eliminate confusing jogs in the Station's western boundary so that test pilots making high-speed firing runs, and also the public exploring the desert, could more easily determine the precise location of the boundary. The proposed line was along the high-tension electrical power line in that area.

The east extension, an area of approximately 10,360 acres, embraced lands between the boundary of the NOTS village and the Ridgecrest-Tiona road. Although in the acquisition request it was termed the "east extension," it was actually an extension of the Station's southern and eastern boundaries. This proposed extension was intended to provide a buffer zone so that any future expansion of the outside communities would not be too closely adjacent to the NOTS village area. As Burroughs told Byrnes, the extension was needed "to protect us from people putting up these honky-tonk places right across the road from the station."²⁶

A fourth proposed extension never went beyond limited discussion. This would have extended NOTS, with its full width of 30 miles, to a distance of 150 miles northward and close to the town of Tonopah, Nevada. A testing range of this dimension would have been particularly useful for the postwar guided missile programs of the Navy, but during the war it was not pressed with any vigor and consequently never materialized.

As compared to the rapid-fire achievements in the Station's

technical and building programs, the legal process of acquiring the Station's lands and settling land claims was a slow process. These continued throughout the months--and years--ahead. The process of making settlements was complicated. Neither the Navy Department nor the Department of Justice could settle claims until they were cleared through the Department of the Interior and declared valid. Within the Navy several different agencies and commands had an interface with the claimants, and it was not always easy to determine whether action should be taken by NOTS, the Eleventh Naval District, or the Bureau of Ordnance. This governmental maze often confused claimants leaving them with a distinct impression that they were being given the proverbial runaround. As an example, Burroughs with full honesty had to respond to a concerned mine owner as follows:

I cannot give you any definite information as to the action that may be taken in Washington on this proposed acquisition, nor whether it will be a permanent acquisition or merely for the duration.²⁷

A particularly distressing but necessary action was that of moving out those who had homesteaded within the area claimed for the Station. Although but few homesteading ranchers had to move, the uprooting process was a painful one according to some observers. Duane Mack, one of the first CalTech staff members to work at the NOTS ranges, gives this reaction.

I knew the ranchers that were in the area. You see when we first came here we'd go in there for water because they all had little wells, and we got acquainted with them. They were wonderful people. I just had a lot of respect for them because they were real pioneers in my opinion. You knew... without water, without electrical power,... they'd carved these little ranches out of the middle of the desert and the conditions were pretty darn rough. So we liked them and they were extremely concerned because they realized they were probably going to have to move. And they didn't know where to go. Many of them had come here as young people and a lot of them were elderly--and where would they go?... In talking to them I felt what they were offered for the land was very inadequate. Some said and some refused to sell.²⁸

From Commander Richmond, NOTS Executive Officer, we have another reaction,

... in the early days we moved about 6 or 8 families off the Station and relocated them over here just this side of Route 6 [now Highway 14] but off the Station and there were some who were unhappy about it but apparently they didn't complain too bitterly.²⁹

The Department of the Interior did not approve the request to transfer the lands outright to the Navy. Instead, a temporary-use permit was issued, to expire six months after the termination of the declared national emergency. This decision not only preserved the

status of the unclaimed lands in the public domain, but also left the Department of the Interior untrammelled in such complex matters as grazing rights and mining claims. No battle line was drawn over the issue. In the face of a real war the Navy did not wish to open fire in an interagency skirmish as long as there were no immediate obstructions to building NOTS and getting test operations under way. Thus NOTS would be built and operated during the war and the immediate postwar period on a permit that gave it but temporary use of unclaimed lands in the public domain.

A NATURAL PRESERVE

The Navy's arrival on the Mojave not only moved back the frontier but it also resulted in the preservation in its natural state of most of the 1,095,926 acres that would come into its borders. This area contains many unique features. Among these is the most extensive display of Indian petroglyphs in North America, totaling over 14,000 different images chipped into stone by Indians as long as 3,000 years ago.³⁰ It contains the historic Coso Village site. Feral horses freely roam the upper reaches of the ranges without fear of ill-intentioned men with guns. It provides one of the last California refuges for the free-roaming burros whose ancestors came with the first land parties of the California missionaries and whose later generations carried the supplies of the prospectors and miners who opened up development of the desert. Animal and plant life exists in most of the area much as it did in 1943, relatively safe from the encroachments of civilization. A few changes have been made like the introduction of the chukar game bird, but these have only enhanced the value of the preserve.

The contemporary view of the advantages of the desert location was limited. The founders, albeit men of foresight in matters of science and the needs of the Navy, saw the desert as a beastly place—a place without its own set of attractions for living. They saw the advantages of good flying weather, and lots of it, available water, power ready to be tapped, and lots of space. But as a place to live, to bring a family, that was where a price would be paid. A chronic recruiting problem was foreseen. The time would come when improved transportation, recreational growth, community development, and advances in air conditioning would cause people to prefer this “land of little rain” to the cities with their traffic and smog. But the

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metamorphosis was just beginning. In 1944, Indian Wells Valley, including the swollen villages of Inyokern and Ridgecrest and the planned town of China Lake, was still a place to go through and not to—unless your wartime orders or duties required otherwise.

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- NA National Archives, Washington, D.C.
- FRCB Naval Weapons Center records stored at Federal Records Center, Bell California

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3

Flood Currents in Rocketry

The urgent drumbeat of war was quickening when NOTS was established. And the new Station lost no time falling into the brisk step of the compelling tempo.

As was noted in a previous chapter, test operations began within a month of the Station's establishment. Subsequent to Burroughs moving his headquarters from Inyokern to China Lake in April 1944, operational resources multiplied rapidly. We will now see how the Station operations in support of the CalTech rocket development and the Navy's rocket training program began to have an immediate effect on the quality of the weapons and their usage in the war.

FOWLER FOLLOWS THE ROCKETS TO WAR

The day-to-day technical progress in rocketry was apparent with each successful test at the recently established NOTS. But the real measure of rocketry in this era was its performance in battle.

To obtain a brief view of the initiation of American rockets into the battles of World War II, we will follow the trail of Dr. William A. Fowler, Lauritsen's number one man in the technical direction of the program, in his tour of the Pacific combat theaters shortly after NOTS was founded.

Fowler started his mission by visiting headquarters groups to learn how the rockets were being used in battle and to determine what he or his associates back in Pasadena could do to aid weapon introduction into the Fleet. He promptly passed what he had learned

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Courtesy Millikan Library, California Institute of Technology

Dr. William A. Fowler, Assistant Director of Research for the California Institute of Technology rocket program.

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to his CalTech peers—whether facts or statistics, or personal impressions and feelings such as those expressed below.

12 Mar 44

Dear Staff:

This is being written because I feel that each and every one of you should share with me an experience which truly belongs to all of us. It is being written aboard a C-47 (DC-3) of the Air Transport Command bound from one of our island fortresses to another, getting closer to the real McCoy every minute. Accompanying us is a Navy squadron with our gear aboard. They are following us because we have a navigator and this is a long, overwater hop.

After taking off from our last stop we circled the field for quite awhile and we all wondered what was up. Then all at once the squadron swooped up alongside of us and we were off in formation with the transport in the lead. When I noticed four rails [70-inch CalTech rocket launcher rails] on each and every wing I got so excited I almost started to cry. Now for over an hour I've been watching them, just fascinated. Here is our gear going up to combat, and I'm so damn proud of it and all of us that I can't help writing this letter. Sentimental or not sentimental, they can't stop us now! This squadron happens to be the one which adopted insignia with three of our gadgets "rampant." To me it is a symbol that we are doing our part and that our part, our share, is contributing to the final victory.

I showed several reels of the 16 millimeter movies to Admiral Halsey and talked with him briefly. His command outfitted a squadron in the field some time ago and it has been very successful. The Admiral wants more planes and more ammunition and now he is getting what he wants—this squadron alongside is very real proof of that fact.

More and more must come and all us must redouble our efforts to keep it coming. Don't doubt for a minute that the boys out here want it and will use it. Theirs is the toughest job of all and they want everything in the book to throw at the enemy.

With my best regards
WILLIE FOWLER

P.S. I plan to mail this the minute we land, before I get self-conscious about it.

As one of the scientists to become involved in rocketry just prior to United States entry into World War II, Fowler had witnessed the skepticism and general indifference to rockets then prevailing within the armed services. All that was now changed, and Fowler was impressed by the phenomenal speed with which the Navy was coming up from behind.

The most striking evidence of now the Navy could so quickly rise to an emergency was seen in the aircraft with their rocket launchers. The program for these rockets had started only nine months before. The rocket-equipped Fleet aircraft were but the

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forerunners of thousands already being similarly equipped. And it would not be long before orders would be issued that all carrier-based and twin-engine land combatant type aircraft delivered by the contractors be fully equipped to fire rockets.¹

Although Fowler and the other CalTech scientists were enthusiastic about the unprecedented progress in rocket development, it was not known whether this enthusiasm was shared with the armed services who had but recently been called on to use the new weapons. This was the kind of feedback needed back home, at Pasadena, and at NOTS.

Fowler flew 21,000 miles in 66 days, a period that he broke down into 53 days of active work, 6 days and 4 hours of flying, and 7 days "sweating out" visit and transportation requests. He visited the headquarters of Commander in Chief, South Pacific, Admiral W. F. Halsey and the U.S. Army Forces, South Pacific Area in New Caledonia; the Third Amphibious Command at Guadalcanal; the Fourteenth Army Corps and the Thirteenth Air Force at Bougainville; Headquarters, U.S. Army Forces in the Far East in Australia; the Second Engineer Special Brigade in New Guinea; as well as numerous combat areas. He "talked rockets" at all levels throughout the Pacific—with admirals, generals, other officers, and enlisted personnel. How were rockets used? What were the problems? What could the scientists do for the fighting men?

The CalTech emissary was especially interested in learning of the first use of aircraft rockets in the Pacific. Apparently, in December 1943, Marine Corps Squadron VMTB-134 had received a shipment of experimental rail launchers that had been dispatched to Halsey's gunnery officer; it was understood that the rockets would follow within the month. To assure the earliest possible use of the new "secret" weapon, 22 TBFs were immediately equipped with eight Mk 4 rocket launcher rails apiece. There were no accompanying blueprints, drawings, or instructions, and a determined crew went to work on the puzzle. The initial installation required more than 300 man-hours for the first TBF; however, this time was reduced to only 16 man-hours by the time the last aircraft had been equipped. Despite the problems, initiative and ingenuity triumphed, and the launchers were ready. All that was lacking now were the rockets themselves; however, a tired, but proud, crew was confident that there would be no delay in getting the new weapons into combat against the enemy. What they did not know was that a higher priority use had been assigned, and the rockets, so eagerly awaited,

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were being sent to the carriers in the Atlantic Theater. Also, the rocket supply was as yet quite limited because of certain fuze problems that were being ironed out in the desert at Inyokern.

Each day of waiting for the rockets brought fresh reports of targets seemingly ideal for the new weapon. Halsey's aviation units were harassing land installations and shipping around Rabaul. Intense anti-aircraft fire made it hard to get close enough for accurate bombing. Hopefully, the new rockets could do the job. This optimism for a weapon—albeit untried in battle—was an extension of the aura of high expectation that had characterized the 3.5-inch aircraft rocket project since ComInch had launched it six months earlier.



First forward-firing rocket used at sea: loading 3.5-inch aircraft rockets on carrier U.S.S. *Mission Bay* in late 1943.

The month of January slipped by and still no rockets were forthcoming. The pilots of the 22 TBFs were beginning to have unkind thoughts about rockets in general and launcher rails in

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particular. Four 70-inch-long rails projecting out from under each wing caused enough drag to reduce airspeed by about 5 knots, thereby increasing the advantage of enemy fighters as well as cutting down the effective range of the TBFs. One pilot with this handicap reported that 17 planes without launchers passed him in 15 miles.

Finally, a cargo ship arrived in Noumea harbor, and someone found she had rockets aboard. Halsey issued orders that they be delivered to the rocket squadron with highest priority.

The ship's officers knew exactly where the rockets were—at the bottom of the hold covered by assorted material that would take days to unload. But the pilots had waited long enough! Through their demands, an unorthodox solution was found—an acetylene torch to cut through a steel bulkhead. An ordnance officer told Fowler that the packing crates were scorched, but the rockets were in good shape. The enthusiasm with which they were unloaded approached that for the Christmas mail!

The precious rockets were air transported to VMTB-134, which had moved to Bougainville. As a strike was imminent, there was little time for training and practice with the new weapon. Within three days, the pilots and crews improvised their own familiarization program. On February 15, 1944 (only a week after their "liberation" from the ship's hold at Noumea), the first U.S. aircraft rockets were fired in the Pacific Theater. Their targets were large Japanese transport ships in Keravia Bay, in the Rabaul area of New Britain Island. John E. Burchard describes the strike:

Coming down to their attack through heavy antiaircraft fire, they fired their rocket at practically point-blank range (500 to 600 feet). Two of the pilots pulled out of their attack run before they could see whether they scored hits, but reported that they didn't believe they could have possibly missed. Two other pilots saw their rockets hit.²

Major A. C. Robertson's Marine pilots undoubtedly felt that the Rabaul strike was an exciting blow for victory as they watched their rockets slam into the large transports. This excitement dimmed when post-mission assessment showed the actual damage to be relatively slight. When Fowler heard this, he understood at once why this was so.

The rockets sent to Noumea were of two types, neither of which was designed for the tactical application for which they were used. One thousand of them were 3.5-inch aircraft rockets with solid-steel heads designed for use against submarines. Although the rupture of a submarine pressure hull need not be large to be disabling, the same size hole through the hull of a transport would not have the same

consequences, particularly if above the waterline. There were also five hundred 5-inch ARs with high-explosive heads and fast fuze action for antipersonnel use. This fuze would function immediately upon impact and would not even penetrate the hull of a large vessel. It would also explode at water impact without causing damage to an adjacent ship. The need for a delay fuze was clearly evident.

Finding the rockets ineffective against large ships, the Marines turned with spectacular success to other targets—antiaircraft emplacements that had no turrets, radar installations, and bivouac areas. Fowler was told that the TBFs with rockets damaged so many antiaircraft emplacements that those without turrets no longer fired against TBFs for fear of revealing their positions. Targets were “more than plentiful.”³

By March 7, when Fowler was in Noumea, he learned that a squadron of Dauntless dive bombers (SBD) had arrived at Bougainville fully equipped with rocket launchers and sights. Their pilots had been “trained” in the use of rockets; that is, they had probably fired a dozen or so rockets each during a few days training at Inyokern. They were all anxiously awaiting the arrival of a supply of rockets—but in the meantime, they were taking off their launching rails.

In the same period, another TBF squadron, VC-7 from the U.S.S. *Manila Bay*, had fired two hundred and seventy-three 5-inch ARs during the Marshall Island operations and were credited with 4% hits against small targets of opportunity. The pilots also claimed that a large ammunition dump exploded as the result of rocket hits.

Admiral Chester W. Nimitz's Gunnery Officer, Captain T. B. Hill, had been much impressed by the surprising accuracy of rockets in tests conducted in Honolulu. And the first combat uses by VMTB-134 and VC-7 clinched the impression. Hill told Fowler that the Commander in Chief of the Pacific wanted 100,000 rounds per month. A few months earlier Fowler would have been amazed by the size of such a request for a new item. But he now knew that CalTech itself had just completed the emergency production of the first 100,000 rockets, and industrial plants under Navy contract were beginning to turn them out in production-line fashion. Those who developed, tested, and produced the new weapons were ready to meet the Fleet needs.

Fowler's overall evaluation was that there was great enthusiasm for rockets in the Pacific Theater. He also listed a number of specific observations and recommendations. Despite the progress he had

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observed in the introduction of rockets to the Pacific, Fowler was concerned that the combat theaters were preparing to use relatively few of the rockets that were beginning to come off the production lines.

He reported, "At the present time, approximately one million pounds of rocket propellant are extruded per month and several hundreds of thousands of projectiles are being produced."⁴ By comparison, he doubted whether more than 10,000 rockets had been fired in combat in all the Pacific Theaters combined. Moreover, he pointed out that only a few of the various rocket heads and fuzes designed for special combat purposes had yet been employed in combat. This was to be expected in the introduction of a new weapon, but Fowler wanted to make it clear in his recommendations that considerable groundwork was still needed in order to take advantage of what had been accomplished in both development and production.

At the heart of the problem, Fowler identified the lack of adequate doctrine for the use of rockets. Studies of rocket warfare were needed that would lead to the speedy development of tactical and logistical doctrine. To emphasize the point, he stated that if such studies could not be made, he doubted the merit of large-scale rocket programs in the United States.

Although Fowler noted with admiration the spirit and ingenuity with which field units installed rocket gear and used it in combat, he also had to note that the absence of overall rocket policy, guidelines, and training materials often resulted in excessive man-hours being required for weapon maintenance and handling. In many instances, misfires and accidents were also incurred by these deficiencies.

Fowler was convinced that the difficulties encountered were not the fault of the theater commands, but the result of information not being available on new rocket developments. The services were geared to guns and bombs. To fully exploit the potential of the new weapons, their tactical uniqueness and peculiar logistical characteristics had to be understood all the way from the theater command to the marine, sailor, or soldier who would be facing the enemy with the weapon.

Fowler encouraged the technical writers of CalTech to press forward with operating manuals and procedures. He wrote Dr. Joseph Foladare, head of the Editorial Staff, "I have found G.I.s reading your pamphlets in the most remarkable places and you can feel justly proud of the fact that the works of your office are popular reading

in foxholes, in jungle camps, and in 'sacks' under mosquito netting."⁵ The message was that publications were critical in the scheme of using weapons to defeat an enemy.

Finally, Fowler recommended that a civilian scientific advisor on rockets be assigned to the Pacific Theater. On the basis of his own experience, he further recommended that the advisor be associated with a rocket development group, specifically, the CalTech section of the National Defense Research Committee (NDRC).

In one form or another, Fowler's main recommendations were acted upon. Less by decision than osmosis, a doctrine of rocket use evolved. As rocket successes mounted, there was no question that the services were at last using the new weapon in sufficient quantities to equal the huge production at home. The value of the Fowler visit was recognized, and other advisors from CalTech were later assigned to carry on where he left off. Rockets, whose potentialities had been largely overlooked before World War II, were coming into major military use by midpoint of that war. A new field of ordnance had been opened!

RANGES AND TARGETS

Feedback from the Pacific combat theater influenced the Naval Ordnance Test Station in many ways; not only in the development and testing of rocket hardware, but also in developing its ranges and testing facilities. A case in point was seen in the spring of 1944. At this time Fowler's firsthand observations of CalTech rockets in a combat role were starting to arrive from the Pacific Theater. On March 9 he wrote:

It has been definitely established that instantaneous functioning for anti-personnel fragmentation is of little use since the Japs are always underground or behind pill boxes or block houses. Areas in which all of the foliage and bark had been completely stripped from the trees by fragments and concussion contained live and fighting Japs. The enemy must be dug out by penetration and delayed fuze action.⁶

A month later he addressed his comments in an informal letter to Dr. Robert B. King, supervisor of CalTech's fuze group:

It is my impression that three coconut logs in thickness should be taken as the wood target to be penetrated. Cover the logs with 2' of dirt or preferably sand. Ask Comdr. Renard to have some logs shipped in from Hawaii or dig some up in the States. Don't worry too much about concrete although penetration of at least one foot would be desirable.⁷

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He closed his letter with the admonition to "keep up the good work and assure your gang that their efforts are really worthwhile."

And so some of the earliest special-purpose targets constructed at NOTS were simulated Japanese gun emplacements fortified with logs; however, it is not known whether these logs were "shipped in from Hawaii or [dug up] in the States." Concrete reinforced pillboxes—described in a CalTech report as being of "native elaborate Japanese design"—were also constructed.⁸ NOTS was not the only site of pillbox targets; some were built on San Clemente Island off the southern California coast. Several rocket rounds were fired at these targets in March 1944.

The building of ranges and targets enjoyed top priority at the desert Station in early 1944, as dictated by the urgency of the CalTech program. Although there had been much progress since the initial drive of a single bulldozer marked out the first air firing range on the desert floor, the range facilities in early 1944 were relatively crude when compared to the highly sophisticated test ranges of a latter-day NOTS. More often than not, a "range" was the hasty rearrangement of the desert terrain by the ubiquitous bulldozer into the form of earthworks, bunkers, and trenches. Wooden shacks and sometimes a lone Quonset hut served to protect test instrumentation and ground crews from the harsh elements of the upper Mojave region. Cables and telephone wires were simply laid down on scrub-covered sand—highly vulnerable to the passage of jeep, construction vehicle, and wild desert burro alike.

Crude as they were, the ranges were helping CalTech to do their job. Besides getting operations under way, the early temporary ranges represented the beginning of the present range complex with its sophisticated systems of collecting performance data on a wide range of ordnance tests.

Construction of even the most temporary range facilities was often plagued by planning and funding problems. But Captain Byrnes in the Bureau of Ordnance continued to give his staunch support to the NOTS-CalTech needs. Not only Byrnes but also some exceptional young reserve officers who worked for him in the Bureau gave their support. One of these was Lieutenant Commander (later Commander) Gerald K. Lake, whom Byrnes described more than twenty years later as being "simply splendid... a remarkable memory... smart as he can be."⁹

Like his boss, "Gerry" Lake was a man of action, possessing a marked talent for sidestepping bureaucratic hurdles. Sometimes his

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initiative surpassed even that of Byrnes himself, as revealed in the transcribed record of a telephone call from Burroughs at NOTS Inyokern, on April 12, 1944. The topic under discussion was a request for construction funds for range facilities:

Lake: Yes sir, I've been working on your \$100,000 ever since you called yesterday.

Burroughs: Have you fixed it up?

Lake: Just about. Here's the thing Captain, I'd like you to answer one question for me, did you make an effort to transfer that \$100,000 through your Pay Master to the Officer in Charge of Construction?

Burroughs: We can't do that.

Lake: That's all I wanted to hear you say Captain.

Burroughs: It just can't be done out here, it has to be done back there.

Lake: That's the information that I got from Bureau of Yards & Docks. The thing that concerns me was that Captain Byrnes was not confident that it could be done. I felt that rather than delay matters by having a lot of arguments as to whether it could be done or couldn't be done, I would try and get the thing straightened out so that you could get going this afternoon. If I tried to transfer O&OS over to Yards & Docks I'm going to run into more delay because there will be arguments as to whether that appropriation is available. You told Captain Byrnes that that \$50,000 I think it was, item was to prove test and experiment. However, since it's concrete targets and roads, it is possible that the Financial Division might object, again resulting in delays so I went to Admiral Kitts this morning and said, "Sir, as a matter of policy I don't agree with this, but as a matter of getting something for Captain Burroughs this afternoon, will you approve my giving Yards & Docks \$100,000 under the appropriation IRNVAA [Increase and Replacement of Navy Vessels Appropriation Act (1944)] about which there can be no argument?" And he heard my story and he said yes.

Burroughs: That's swell.

Lake: I will go down this afternoon, I've got the letter written here but I haven't read it and deliver by hand to Yards & Docks their authorization to spend \$100,000 for the 5 items that are included in your personal letter to Captain Moses. That's what you want, isn't it?

Burroughs: Yes.

Lake: Then they will call up the Officer in Charge of Construction and tell him to go ahead.

Burroughs: Fine.

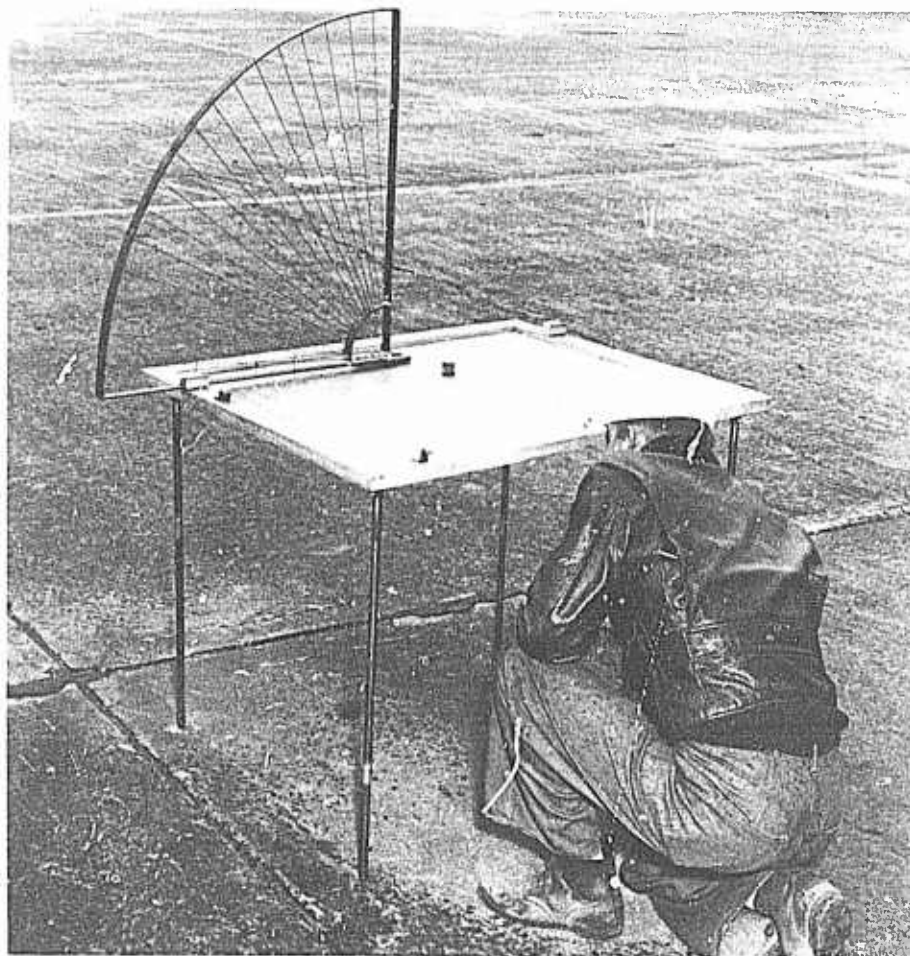
Lake: If anything goes wrong with my plans in the next couple of hours I'll telephone you sir.

In July 1944 a six-month construction effort was providing ranges complete enough for effective testing work. At C-1 Range—the aircraft range located about 12 miles northwest of the Station—the target was still a large white cross in the center of a cleared area 200 yards square. However, a control tower was now in place some 4,500 yards removed, with radio equipment to provide contact with the NOTS airfield and the pilot of the shooting aircraft. In addition, remote stations gave shelter to "stakers" (or spotters) and telephones to notify the tower of the impact for each pass.

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As dive angles and trajectories were critical to rocket firing analysis work, the NOTS range engineers devised an ingenious instrument called a "harp." This was described as a quarter-round gadget with wires radiating out at angles; another set of wires intersected them at points representing distances to target. So, as an aircraft came flying in, the observer could sight through this harp and see what wire the aircraft was following down and get its dive angle and approximate range.¹⁰

Spotting towers had also been built at G-2 Range (the ground firing range for inert ammunition) 8 miles from China Lake. These



The range harp: early NOTS instrumentation used to determine aircraft dive angles during air-to-ground rocket attack.

towers were equipped with rakes—sighting instruments long used in Fleet surface gunnery to determine the impact points of projectiles.

Three months earlier, in April 1944, before the spotting towers were built, Burroughs was concerned about their nonavailability. Accordingly, he wrote to the Bureau of Ordnance and requested six obsolete Army tanks "for use as camera stations and observation posts in connection with rocket and fuze tests."¹¹ There is no evidence that such an expedient was resorted to. Happily for the prospective occupants of such a shelter during a Mojave summer, the spotting towers were built and soon operational.

Special-purpose ranges were constructed to handle special problems and programs. For example, a plate range designated K-1 was established for the critical fuze testing program. In addition to steel-plate targets of varying thicknesses arrayed in staggered rows, a permanent 30-foot launcher (a length of steel rail that constrained the rocket) was also in place at K-1. At a companion plate range (K-2) a similar 200-foot launcher was nearing completion.

Yet another special-purpose range was located 26 miles away from the Station. This was Area L—also to be used for fuze tests, tests of high explosives, and any test that required the aircraft to be landed nearby. For these reasons, Area L was chosen for its remoteness and the proximity of a dry lake bed smooth and long enough to be used as a landing strip. It was here that the earlier mentioned Japanese pillboxes were constructed.

The program was not limited to obtaining ballistic data on rockets in flight; underwater behavior of rockets also posed many unanswered questions. How strong does a rocket body structure have to be to withstand breakup on water impact? What trajectory changes are imposed upon water entry? What are the velocity changes? How about penetration, fuzing? Though its comprehensive work on the air-launched torpedo for the Office of Scientific Research and Development, CalTech was able to provide some answers. But theoretical data for torpedoes had to be extrapolated for aerial rockets, and the application had to be tested. The torpedo testing facility at Morris Dam was totally unsuitable for aircraft rocket tests because of its topography and small size; consequently, NOTS sought an underwater range within reasonable flight time from Inyokern. Haiwee Reservoir 40 miles to the north appeared to be a perfect solution. As it was part of the water supply system feeding into Los Angeles, permission was needed for its use. This was given under conditions safeguarding against water contamination. It was also

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stipulated that no live warheads be fired into the reservoir. Further, the conditions imposed on the use of Haiwee made it necessary to obtain the use of Walker Lake in Nevada for underwater firings.

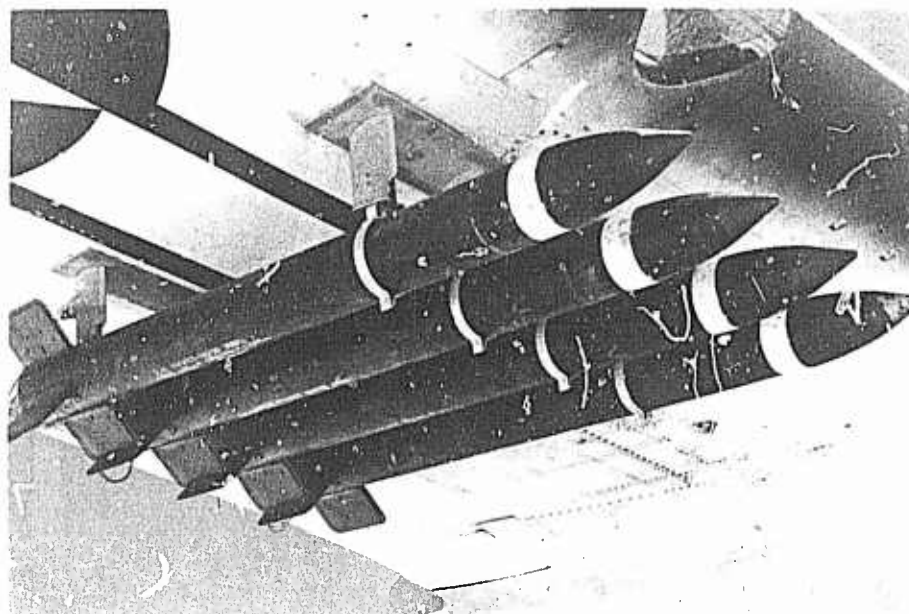
In the meantime problems were appearing with NOTS firing of inert rockets into the Haiwee Reservoir waters. Under the conditions prevailing, the compression forces of the rockets were killing large numbers of the fish, mainly carp. In one case, Duane Mack recalls that, to prevent contamination, 50 men from NOTS were sent in with gunny sacks to pick up 3,500 fish. This was one of the reasons that, after thirteen months, NOTS lost the use of this nearby underwater range.

Following the history of the test ranges from simulated Japanese dugouts to underwater ranges gives the impression that the wartime development of NOTS ranges was a continuous string of practical adaptations to meet immediate needs. This is but half of the story. Simultaneously with the day-to-day scurries to adapt to war needs, there was a persistent, albeit second priority, effort to build well-planned facilities for efficient handling of the long-term needs. With a quiet, steady pace this work went forward. In brief it can be stated that at the end of World War II, NOTS emerged not only as a lead laboratory of the Navy, but it could also claim the most completely instrumented ranges in the nation for rocket and midrange guided missile testing.

"HOLY MOSES"

In 1944 the main focus was not on ranges but on rockets for the war. Among these none had greater potential for battlefield impact than the new 5-inch high velocity aircraft rocket (HVAR), the progenitor of a second breed of aircraft rocket. It would make history for NOTS and the nation.

To appreciate the historical significance of the 5-inch HVAR, its relationship to the early efforts to develop aircraft rockets must be established. It will be recalled that the United States lagged far behind the enemy, Germany, and behind such allies as Great Britain and Russia when it entered World War II. That the United States at the end of the war had the most effective aircraft rocket, the HVAR, and was employing it in the largest numbers and with the greatest effect represented a remarkable achievement in the annals of ordnance development.



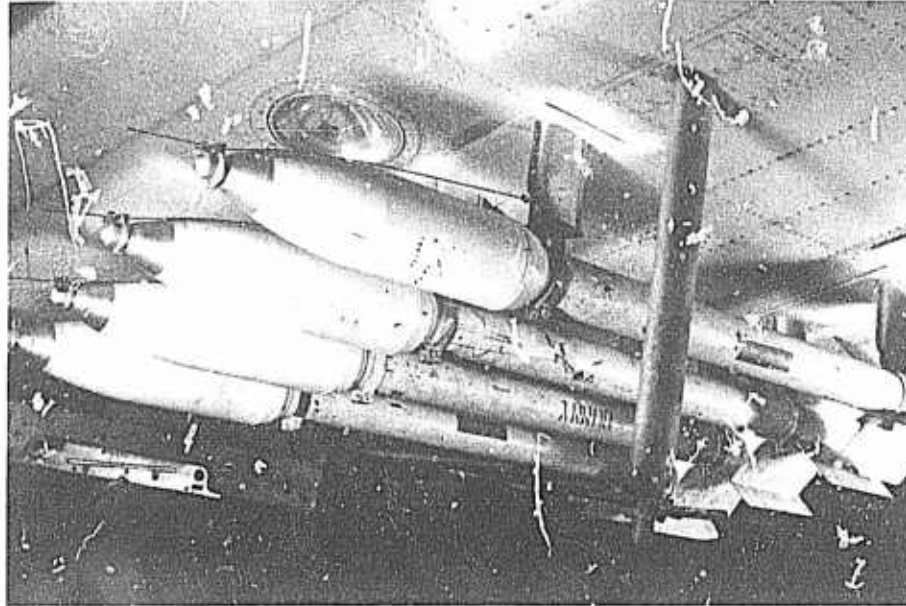
A B-25 light bomber equipped with 5-inch HVAR Holy Moses.

But the success of the 5-inch HVAR cannot be separated from its predecessors, the 3.5-inch and the 5-inch ARs. Together they stand as an achievement of a military-scientific-industrial team that, by the middle of World War II, had reached a peak in its newfound capabilities. All that it had needed was the order to give aircraft rocket development a top priority, and Admiral King had provided that.

As the volume of rocket testing grew, so did the learning and experience of both developer and user. The 3.5-inch AR had performed fairly well and with sufficient velocity to be reasonably accurate. But while the expedient of installing a converted 5-inch artillery shell as a warhead (the 5-inch AR) improved the on-target effect, the extra poundage up front cut flight velocity and hence, accuracy. After several explosive tests, CalTech determined that the shrapnel-making capability and particle pattern of this projectile were excellent. Fowler is reported to have said, "You can't improve on this head that Dahlgren has already spent years developing."¹²

The need was obvious, a rocket with the velocity of the 3.5-inch AR and the explosive power of the 5-inch AR. The job was to design a new motor. A solventless-extruded grain was developed with a cruciform cross section. As early as December 1943, versions of the

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The 5-inch aircraft rocket installed on zero-length launcher.

new motor had been ground-fired at Goldstone Range. The rocket's official designation was the 5-inch High Velocity Aircraft Rocket (HVAR). But thousands eventually came to know it as "Holy Moses." There are different accounts of how the rocket acquired its irreverent nickname. The commonly accepted version is that Conway W. Snyder of CalTech's projectile design group exclaimed "Holy Moses!" as he witnessed the powerful blast of the rocket.

The new aircraft rocket's overall length was 73 inches, and its weight was 140 pounds. Not only did the designers achieve the velocity of the 3.5-inch AR, they improved on it by getting 1,375 feet per second—a gain of 200 feet per second. Two models were eventually developed: one with a base fuze and a semiarmor piercing head; the other with both base and nose fuzes. Instead of the customary single nozzle, the motor had eight peripheral nozzles and one central nozzle.

Despite the fact that the ground-testing phase had taken place at Goldstone, Holy Moses was the first brand-new aircraft rocket to be air-tested at Inyokern, and also the first to be exclusively identified with the youthful desert test station.

Lieutenant Commander Curtis Vossler later recalled that Thursday, March 30, 1944, was a fine day with no wind. He and

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several brother pilots of Aviation Ordnance Development Unit 1 (AODU-1) were spending the week at Inyokern on a very busy schedule of rocket testing.



Concrete wall target hit by Holy Moses.

Vossler had already made four rocket firing flights that day, shooting a mixed bag of 3.5-inch ARs and some subcaliber combat training rockets, and was ready for a fifth one. At this time it was casually noted that the ordnancemen had unceremoniously installed two new rockets on TBF-1C #24516 along with four 3.5-inch ARs. Holy Moses was ready to be test-fired in the air!

Vossler and Lieutenant John M. Armitage flipped a coin to see who would take the flight. Vossler won the toss. Pollock later recalled the incident with characteristic good humor: "Those conniving buzzards pulled a fast one on me. They stuck a daily flight schedule on my desk to sign without pointing out that HVARs were [to be fired] that day for the first time. They knew it was my policy to make the first flights...but they figured they'd get one out on me. I guess, I signed the thing without checking it too closely [and] they went out and flew it."¹³

It was a horizontal firing at 10,000 feet. Performance met all expectations. To Vossler in the cockpit of the TBF, the greater velocity of Holy Moses was immediately noticed, but as he said later,

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"we *expected* to notice it." While specific details of this important test were not recalled, Vossler added, "The only thing that really sticks in my mind is that it was successful."¹⁴

That would be the story of Holy Moses. One success after another through its whole development cycle, from inception to combat use; a cycle of almost unprecedented brevity—little more than six months. This success is reflected in all the air-firing test reports at Inyokern, both in the large numbers fired from many different types of aircraft and the few problems apparently encountered. The six-month development cycle is all the more remarkable when one considers the scope of the entire program, embracing internal and external ballistics, safety precautions, assembly procedures, launcher installation, fuze behavior, and sighting tables that were concurrently derived and delivered as a package with the operational round in July 1944. Also to be considered is the successful design and test of zero-length wing launchers for the 5-inch HVAR (including one for the Army's P-47 Thunderbolt aircraft).

Holy Moses established a new leadership for the United States in aviation ordnance that would be maintained for decades to come. Navy and Army Air Corps aircraft now had far greater striking power than ever before. Aircraft had the hitting power equivalent of a 5-inch shell in each rocket they carried. As compared to attacks with machine guns alone, their exposure to defensive firepower during the deliveries was greatly reduced. The attack pilots now had what they had long sought: an effective and reasonably accurate weapon against small targets such as submarines, destroyers, shipping, antiaircraft positions, ammunition and oil storage dumps, tanks, and locomotives. And in the combat arenas of Europe and the Pacific they courageously applied this advantage to good measure.

But credit for the wartime success of the naval aviation combat units with rockets should be shared with a small group of naval aviators—the test pilots of NOTS—who, despite continuing attempts by their leaders, received few formal honors in recognition of their hazardous duty. These men, together with a tough, hard-working aircraft maintenance team that kept them flying, constituted the Naval Air Facility at Inyokern.

Naval aviation support was a vital aspect of the desert Station's mission and a crucial necessity for fulfilling its primary function in the "testing of weapons." And yet, from the onset, difficulties were being *revealed* in the air operations capability at NOTS. Although dismissed as inconsequential by some, these difficulties appeared to

others as having a dangerous potential—one that might conceivably have an adverse impact on the rocket program.

AIR FACILITY PROBLEMS

Although Burroughs moved his headquarters from the Inyokern airfield in April 1944, he did not leave behind the problems plaguing that air facility.

Ironically, outward appearances seemed to belie any existence of problems; on the contrary, the air facility appeared to be vigorous and essentially healthy. Such a conclusion would have been easily reached in view of the sheer volume of aircraft activity over the Indian Wells Valley: planes of AODU-1 making rocket flight tests; squadrons of Fleet aircraft arriving and departing and conducting training sorties; the constant traffic of aircraft carrying freight and passengers; and the full-time maintenance and refueling operation of a carrier aircraft servicing unit on the ground.

But appearances are deceptive. What appeared to be a unified air operation run by the new Station was in reality a loose group of distinctly separate organizations. Their only common bond was the fact that they were all generally associated with the forward-firing rocket program, and that they all operated from the same airfield—Inyokern.

The crux of the problem was centered in the fact that the flourishing air facility was not formally a part of the NOTS command.

Ostensibly, the various air units at NOTS—AODU-1, Carrier Aircraft Service Unit (CASU) 53, and the Fleet squadrons—were tenant activities assigned to the Station and as such were subject to the standing orders of the host command. But as far as technical guidance and support were concerned, they depended on ComFAir, West Coast, and their reporting channels were in a direct line to San Diego.

There is no evidence of any conflict resulting from the complex and delicate command structure at NOTS during the early months. Rather, the officers in charge of the tenant units, to a man, seem to have enjoyed a warm relationship with Burroughs. Consequently, there were few problems that could not be ironed out through an informal chat by a warm stove in the headquarters Quonset hut.

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Nor did the tenant units feel compelled to stay in close touch with their parent organizations. As a former AODU-1 pilot put it, "There was never any doubt in the minds of those who were doing the work up here [NOTS] as to where we fitted in, and we let the paper work go ahead as it would and proceeded to do our job." The Commanding Officer of AODU-1, Tom Pollock, was even more philosophical regarding command relationships. As he later recalled, "It didn't make any difference; we all belonged to the Navy and the United States."¹⁵

At higher levels, however, cognizance was traditionally a matter of concern. At the same time he had designated NOTS as an activity of the Eleventh Naval District, the Secretary of the Navy, Frank Knox, had directed Bureaus and offices concerned to take necessary action. Immediately following this, the Commandant, Naval Air Center, San Diego, proposed the establishment of a Naval Auxiliary Air Station at Inyokern under his jurisdiction.¹⁶

Hussey objected. His position was that the principal function of the Station was research, development, and test of weapons. The aircraft testing of the weapons and the training in the use of the weapons were concerns of the NOTS Commanding Officer. He recommended that the Inyokern airfield be operated as a naval air facility under the Commanding Officer of NOTS. Although there were no official orders, the net effect was that Hussey had won his point for the time being.

In what would prove to be a long campaign for control of the air facility at Inyokern, this early exchange between the Commandant, Naval Air Center, San Diego, and Hussey represented only the first desultory shots of random skirmishes.

The cause of the struggle was not merely a question of command prerogatives. The main problems stemmed from a much more tangible commodity: aircraft.

In brief, aircraft were absolutely essential to the success of the Bureau of Ordnance rocket program at NOTS. One officer put it succinctly, "If you run a program . . . you must have control of the assets. If you don't have control of the assets, you're not running it."¹⁷ In the NOTS program, a principal asset was the aircraft used to air-test the new rockets. And according to a long established, and inviolable, tradition, the aircraft of the Navy belonged to the Bureau of Aeronautics. This fundamental dominion and control was implicit from the moment a particular aircraft was purchased and a Bureau number was assigned. For as long as that particular aircraft remained

in service. Its life was subject to the strict system of checkout, maintenance, and modification as prescribed by that Bureau.

Such a system, the Bureau of Aeronautics felt, could only function in an organization staffed and run by naval aviators; in other words, a traditional air facility controlled by the Bureau of Aeronautics and operating in an air base command structure.

At Inyokern, the NOTS proponents for local control of the air facility and the aircraft also had a valid point of view.

The experimenters felt that it was important that they have the freedom to modify the planes as they deemed necessary to try new installations such as rocket launchers, sights, and controls. In the Fleet, such activity was frowningly regarded as "gadgeteering." Modification to service aircraft had to be accomplished according to a specified procedure with approved drawings at hand. Even in the accelerated tempo of wartime, these changes often took months. The NOTS program could not afford such delays.

If aircraft can be identified as the central issue of the controversy, then one of the additional problems had to do with their procurement for use in the NOTS program. Quite obviously, the experimenters wanted models of the very latest service type. But NOTS was not alone, and within the Bureau of Aeronautics system of assigning such aircraft, there was still competition among all who needed them. For example, the Bureau of Aeronautics would buy only a limited number of any new type aircraft for evaluation of structure, design, aerodynamics, electronic systems, carrier suitability, etc.

Usually there was only one new plane earmarked for ordnance and armament purposes, and this was hotly sought by the Bureau of Aeronautics' Patuxent River facility, which had the charter for all armament testing of new aircraft.

For NOTS to get the aircraft it badly needed, it was thought that aircraft procurement would be greatly enhanced if requirements could be generated directly by an air facility controlled by the Bureau of Ordnance and handled with top priority at the highest level of that Bureau.

Despite fundamental differences in philosophy and deep desires to protect their areas of control, the two Bureaus shared a common concern that made it possible for NOTS to function. This is well brought home by the words of a highly placed officer involved in the air facility controversy; he said, "If Aeronautics at any time [had] really wanted to cut off the Naval Ordnance Test Station, they could

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have withdrawn their aircraft."¹⁸ This was neither done nor even suggested. On the contrary, there was a staunch effort by all involved to "keep them flying" at Inyokern. Nevertheless, the effort continued to be characterized by intraBureau problems for as long as the air facility at NOTS remained without a clearly defined charter. On the local scene at NOTS, Burroughs continued his efforts to realize an integrated air facility under his control.

One of Burroughs' efforts that met with success was his recommendation that the Inyokern airfield be renamed to honor a former comrade, Lieutenant Commander Warren W. Harvey. Burroughs' choice of name was appropriate as indicated in his letter of recommendation:

The late Warren W. Harvey was a brilliant post graduate in Aviation Ordnance. He contributed materially to the development of ordnance for aircraft during his life. He commanded Fighting Squadron Three shortly before the war started and was to a large extent responsible for the development of fighting plane tactics now in use. Such famous fliers as Commander Thach and Lt. Cdr. O'Hare owe much of their success to the gunnery technique and tactics developed by Harvey, and would, I feel sure, heartily endorse this recommendation.¹⁹

But there were personal reasons, too, for the choice. Burroughs and Harvey were classmates at the Naval Academy in the Class of '24; their careers as naval aviators and ordnance postgraduates had been close.

On May 10, 1944, the Secretary of the Navy made the name "Harvey Field" official. At the same time his order stated

The aviation facilities at the Naval Ordnance Testing [sic] Station, Inyokern, California are hereby established under an officer-in-charge and designated:

U.S. Naval Air Facility
Inyokern, California

This is an activity under the Commanding Officer, Naval Ordnance Testing [sic] Station, Inyokern, California.²⁰

On June 28, 1944, Harvey Field was dedicated in a brief ceremony by all the officers and men attached to NOTS. The Station newspaper noted that "Mrs. Harvey, widow of Commander Harvey, was present at the ceremony."²¹

But the formal name and newfound status can be misleading. The airfield was still totally lacking in hangar space. Operations and maintenance were carried out under the harshest of conditions. For example, a contemporary historian noted:

Maintenance of aircraft has been difficult throughout. During the winter and spring, high winds and dust storms prevail. During the summer, temperatures are such that touching a plane without gloves after 0830 results in a burn.²²

However, these were essentially physical problems that would be solved by the overall boomtime construction program at NOTS. Significant improvements at Harvey Field would include the new Kodiak hangar* that could house a four-motor bomber, oiled airstrips, enlargement of the Ship's Service and recreation facilities, and a separate transportation pool.

Progress was obvious. And there was time to appraise the phenomenal achievements to date.

If Burroughs—in his new temporary headquarters at China Lake—used this opportunity for reflection, he may well have noted with satisfaction that the mission of his new Naval Air Facility command some 9 miles away was being fulfilled. The CalTech rocket development program was forging ahead with obvious success, and the Fleet training activity no longer threatened to overwhelm Inyokern's limited resources. Now these resources were at last able to cope with the burden. CASU-53 was up to strength, as was AODU-1, the latter unit having completed the transfer of all its men to Inyokern on June 5, 1944.

Burroughs' original tiny command now represented quite a sizable force. The three principal groups that contained the largest number of on-board personnel were AODU-1 with approximately 250 personnel; CASU-53 with a unit strength of 170; and the permanent NOTS force, which, including headquarters staff, numbered about 300 officers and men.

After July 18, 1944, the term "officers and men" would be figurative only, as on this date 22 Waves joined Burroughs' command. Within a year, the number of Navy uniformed women would grow to 150, functioning in almost every phase of NOTS activity.²³

In addition to the manpower, the Naval Air Facility also now had most of the tools to do its job. The Bureau of Aeronautics and ComFAir, West Coast, had done their part extraordinarily well under difficult circumstances. NOTS now boasted 25 aircraft representing a score of carrier combat and utility types, together with a huge quantity of maintenance, servicing, and repair equipment. The Bureau of Ordnance had also subscribed the appropriate shop equipment necessary for experimental ordnance installations.

The period of calm reflection that began in June 1944 was short-lived. Two months later events happened that impacted significantly upon NOTS and its air facility: CASU-53 was detached from its Inyokern assignment by ComFAir, West Coast; AODU-1 was

*. so called because its prototype was first used at Kodiak, Alaska.

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organizationally incorporated as a part of the NOTS Experimental Operations Department; and the Naval Air Facility was once again 'rested from Burroughs' command.

When viewed within the context of a single month, these events appear untoward and mystifying; but examined individually, a logical explanation for each is revealed. The departure of CASU-53 was not unexpected. As described earlier, their mission was to support the Fleet training effort. The flood tide of squadron aircraft had crested and by August had diminished to a manageable stream. Training target ranges had been established in the Holtville-Twenty-nine Palms area of the Mojave Desert; CASU-53 was no longer needed at Inyokern.

Similarly, the incorporation of AODU-1 within the NOTS Experimental Operations Department had been anticipated from the beginning. After all, the unit was expressly formed to further the forward-firing rocket program, and its mission was tailored to fit the needs of CalTech and NOTS. It made more sense for the Station to exercise operations cognizance rather than San Diego, which was 200 miles away. But although AODU-1 had been closely folded into the NOTS organizational structure, the Bureau of Aeronautics still had a string attached. It was at that Bureau's strong insistence that a naval aviator head up the new Experimental Operations Department.

The abrupt transfer of the Naval Air Facility from NOTS to the newly organized Naval Air Bases Command, San Diego, was quite a different matter, being a direct consequence of General Order No. 210 that established the Naval Air Bases Command to replace the Naval Air Center, San Diego, on August 10, 1944.

The new command was large and powerful, having acquired—in addition to the nine activities of the former Naval Air Center—some 15 Navy and Marine Corps stations, auxiliary air stations, and air facilities. Eighteen days later, CNO Directive OP-31-D21-MLA specifically included the NOTS air facility to further enlarge the Naval Air Bases empire.

Thus, by a stroke of the CNO's pen on August 28, the complex split-command status of the NOTS air facility was essentially restored to what it had been at the start. The only differences were that it was now an officially designated Naval Air Facility, and the parent command was Naval Air Bases rather than Naval Air Center. The net result was unchanged: Burroughs had lost military control of his air facility.

Again the reflexes of the Bureau of Ordnance and NOTS tightened on the rope in the never ending tug of war with the Bureau of Aeronautics and the Naval Air Bases Command of the Eleventh Naval District.

Hussey again took up the cudgel. He pressed the point with the Chief of Naval Operations that operational training was at this time barely a token activity. On the other hand, AODU-1, under the technical control of the NOTS Experimental Operations Department, comprised a lion's share of the total air activity.

Added to Hussey's voice of authority was the persuasiveness of the new Experimental Officer for NOTS, Commander (later Vice Admiral) John Tucker Hayward, whom Burroughs sent to Washington to press the issue.

Commenting about this activity in later years, Hayward recalled,

I went back at Ev Burroughs' direction and fought the battle for the Air Facility and my biggest champion . . . in the Commander-in-Chief's Office [was] Admiral Temple, . . . who then directed this be done. He said it *would* be done. . . . I was convinced if we lost this, that the whole purpose of the place [NOTS] would be destroyed.²⁴

It was done. On October 23, 1944, an OpNav letter "removed the Naval Air Facility [Harvey Field] Inyokern from under the command of the Naval Air Bases Command, Eleventh Naval District."²⁵

THE EXPERIMENTAL OFFICER

Commander J. T. Hayward was not impressed when he arrived upon the NOTS scene on August 4, 1944. Yet, contrary to the impressions of many others who reported in the month of August, it was not the full blast of the Mojave summer that caused the unfavorable reaction. Nor was it the unprepossessing, burned-out desert landscape, although the latter caused some misgivings, as recalled by Hayward many years later:

I pulled up over Red Rock Canyon, and . . . there was nothing . . . I mean, *literally*. There was Harvey Field, and there was a lot of dust in the middle where people were building things. Oh, it was grim!

Hayward's disenchantment had begun earlier when he had learned of his assignment to "this strange place." As he put it:

I was real upset about it because I thought I'd done a real good job at the war. I had a squadron; I wanted to stay at the war . . .²⁶

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But the young commander's career was irrevocably linked with NOTS sometime before the moment of his arrival in the busy cloud of dust in the Indian Wells Valley. As the Station's first Experimental Officer, this outspoken and dynamic naval officer was destined to leave an indelible mark on NOTS.

Hayward's acquaintance with the rocket program began with a visit to CalTech. He met C. C. Lauritsen, W. A. Fowler, Carl D. Anderson, and Richard C. Tolman and from them acquired some sound technical information on the rocket programs before going to Inyokern. It was the young combat pilot's first association with scientists, and his first impression was that they were "crabs"—Navy term for strange animals found on land. But this reaction was soon dispelled when Hayward saw not only their round-the-clock dedication but also the strength of what their scientific methods could do for the Navy's weapon programs. However, there was a world of difference between Pasadena and Inyokern in August 1944.

August was significant for the air operations at Inyokern not only with regard to the Bureau of Aeronautics and Bureau of Ordnance conflict and the organizational shifts that affected AODU-1 and the Naval Air Facility, but also in terms of the rocket testing program itself. "Ev" Burroughs had his hands full. If ever help was needed, it was now!

Part of Hayward's strength in helping, came from his being the "compromise candidate" that the Bureau of Aeronautics and the Bureau of Ordnance had selected to head the Experimental Operations Department. Although not an ordnance postgraduate, he was a distinguished naval aviator with a long string of decorations who brought to the desert Station the personal experience of nineteen months of combat in the South Pacific. He also possessed a sound technical and scientific background, having served as Assistant Chief Engineer in charge of instruments at the Naval Aircraft Factory, Philadelphia, Pennsylvania. For four years he had studied physics at the University of Pennsylvania and at Temple University.

As the compromise candidate of the Bureaus, Hayward was expected to reconcile differences regarding the control of the Naval Air Facility.

To comprehend the complex role of the Experimental Officer, it is important to recall the two-part mission of NOTS during its first two years: to build a permanent research and development capability for Navy ordnance, and to support CalTech's rocket program. Burroughs, Richmond, and Sandquist can be identified closely with

the first part of this mission. The second part was largely delegated to Hayward by Burroughs.

Hayward's interpretation of his role given twenty years later is presented below:

I was the Experimental Officer, and of course Captain Burroughs was the Captain. But I reported directly to CalTech. I worked directly for Dr. Willie Fowler and Dr. Lauritsen. I made all the arrangements to do whatever was required in covering everything from the spin-stabilized rockets to aircraft firings. All of the actual technical work that was done up there was done under the test request and schedules, all put out by CalTech. Dr. Fowler was my immediate boss and so was Dr. Lauritsen. Fowler worked directly for Dr. Lauritsen. Fred Hovde was the boss money man for Section Three of OSRD. The Navy input of course came from the Bureau of Ordnance.⁴⁷



The NOTS-California Institute of Technology team. Left to right: Commander J. O. Richmond, Dr. C. C. Lauritsen, Captain S. E. Burroughs, Jr., Commander J. T. Hayward, and Drs. W. A. Fowler and E. L. Ellis.

As revealed by the above, one of the prime attributes of the Experimental Officer was the ability to get along with civilian scientists and be responsive to their needs, and yet exercise the duties and responsibilities of a professional naval officer to maintain an

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effective military support structure. A special kind of personality was crucial to be able to function and deliver under a schizoid command structure, and "Chick" Hayward was such a personality. He became known as a very human character, who not only was predisposed to buck the system when it slowed progress, but also was a grand master in that particular science.

A NOTS organization chart dated September 1, 1944, shows the scope of the Experimental [Operations] Department headed by Hayward (Appendix C). Beginning with a top echelon comprising Ordnance School, Pilot Plant, Harvey Field and Air Unit, Laboratory, Ground Projects and Gunnery, 80 subsequent organizational base elements are shown on the chart.

That Burroughs was content to delegate responsibility and authority for so many of the Station's key functions is testimony enough to his style of leadership and his confidence in Hayward. In a nutshell, the organization worked—and worked well.

While Hayward's organization effectively supported the civilian technical efforts of CalTech, there was concern that there would be future problems in having all of the experimental operations in a department headed by a military officer. Commander James A. Duncan, the Laboratory Officer, predicted that as NOTS was able to move into the research and development roles called out in its long-term mission, there would be difficulties in recruiting and retaining civilian scientists of merit into an organization where they would report to military officers for supervision of their technical efforts. A predominant characteristic of Hayward's Experimental Operations Department was that its top echelons were staffed mainly by young military men subject to frequent reassignments.

Meanwhile, in a wartime situation, the organization thrived. After all, the few civilian scientists at NOTS were part of CalTech, and the wartime program emphasis was on weapon testing.

Hayward established the pattern for an impressive list of distinguished officers who would follow him as NOTS Experimental Officer.* Although there would be a decline in the responsibilities delegated to the first Experimental Officer after the war, the importance of the position (known as Plans and Operations Officer and subsequently as Technical Officer) would be preserved.

* During the first twelve years of NOTS' existence (until 1955), there were six Experimental Officers of whom five ultimately achieved flag rank. These are: J. T. Hayward (1944-47), J. P. Monroe (1949-50), T. H. Moorer (1950-52), T. F. Connolly (1952-54), and T. J. Walker (1954-55).

A "REALLY BIG ROCKET"

Much has already been said about the summer of 1944 and its seemingly climactic significance for the Naval Ordnance Test Station. Some of this significance relate to the development of CalTech's brand new rocket that had arrived at NOTS for air testing in the spring. By prevailing standards and aircraft this was a huge rocket, measuring nearly a foot in diameter.

The rocket had its genesis in "Charlie" Lauritsen's direct and simple logic. If a rocket 5 inches in diameter could be fired effectively against small targets by an aircraft, why could not a larger rocket be developed that could be as effectively employed against ships heavier than the destroyers? It could be fired, he believed, from higher altitudes and at longer ranges than could aerial torpedoes.

Characteristically, Lauritsen discussed the possibility of a "really big rocket" with various naval officers and his own staff. The consensus was that the project was worth exploring. The wartime family relationship between the Navy and OSRD was flexible enough to allow CalTech to develop the original design and proposal without a formal request by the Navy. Early in March 1944 Lauritsen presented calculations to the Navy to demonstrate the practicability of a large-caliber rocket. Captain H. B. "Brownie" Temple was impressed; as a result, his boss, the Chief of Naval Operations, directed development of the rocket at the highest priority, since according to his philosophy, "the main strength and offensive striking power of naval aviation lies in the carrier based aircraft squadrons."²⁸

Practical considerations determined the size of the mammoth rocket, which was ironically nicknamed Tiny Tim. There are no clues as to why or by whom the nickname was chosen beyond the obvious irony that Tiny Tim was one of the mildest and gentlest of Dickens' fictional characters. The rocket was supposed to weigh less than 1,000 pounds so that it could be carried on aircraft installations designed for 1,000-pound bombs. To speed production it was desirable to select a size in which there was commercially available steel tubing. It was also desirable that the size be compatible with some existing bomb or shell adaptable for use as a warhead. A diameter of 11.75 inches was that of a readily available 500-pound semiarmor-piercing bomb, as well as the size of a standard oil-well casing. This casing was in short supply during the war. In an NDRC Summary Technical Report, Conway Snyder writes, "...we were reduced for a time to

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The "really big rocket"—Tiny Tim.

the expedient of salvaging [oil-well casing] from abandoned oil wells."²⁹

No press was available for extruding a propellant grain large enough for Tiny Tim. For this, as well as other technical considerations, a historic first in the shape of a multigrain motor was designed using four grains, each weighing about 40 pounds. The total propellant weight was 149 pounds, a fact not overlooked by pilots who foresaw that they would be asked to take this aloft and fire it from their aircraft. It was less than reassuring when the blast from one of the completed four-grain motors lifted the concrete roof off the walls of a static firing bay at Eaton Canyon and flattened the walls outward. From that point on full-size motors got their static tests in the open desert at Inyokern.

By late April 1944 a complete round was successfully launched from the NOTS ground ranges. But firing a half-ton experimental rocket from the ground was only one step toward the vastly more difficult task of launching it from the air.

Of critical concern in an air launch was the effect of the blast on the aircraft. Field tests showed the rocket had to be at least 4 feet from the aircraft before the motor ignited.

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A special ground launcher for Tiny Tim made of steel girder was erected on the desert at Inyokern. A TBF fuselage was placed near the launcher so that the center of the round was 4 feet from the open bomb bay door. Three rounds were fired. The *CIT News Letter*, No. 1, May 15, 1944, laconically summarizes this important test:

Results of this firing lead to the conclusion that launching of the 11.75 AR from aircraft will be possible.



TBF aircraft used to ground-launch first Tiny Tim rockets.

For five weeks in early summer 1944, testing at NOTS reached fever pitch in efforts to translate feasibility into practicality. The key to this was to perfect a launcher for the huge rocket. One was quickly built: a massive device consisting of twin tubular frames pivoted at one end in the bomb bay. The round was designed to swing down on cue from the pilot and fire when it reached the bottom of the arc. This formidable assembly was called a "displacement launcher," but pilots who saw this aerodynamic nightmare undoubtedly had other names for it.

For two weeks the Station personnel were treated to the strange sight of a TBF—first, only a fuselage, then an in-service model—perched atop a 12-foot-high platform with the engine running. From some remote location a contact was closed, the displacement

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launcher would swing violently down, and a Tiny Tim would hurtle across the desert. Buried in the report of the first such test on June 9 is an ominous notation:

The only injury to the aircraft was to the elevator, each rib of which buckled about 5 in. from the trailing edge. It was thought that this was caused by reflection of the blast from the ground, and that such damage would not occur in air firing.³⁰

This blast damage to the TBF's elevator was wrongly diagnosed and, although passed lightly over at the time, was clearly the first harbinger of a later tragedy.

There were some doubts from the outset of the practicality of the displacement launcher. An alternative method was considered briefly; simply to drop the rocket as one might a bomb, and have a lanyard (fixed to both rocket and aircraft) ignite the propellant. To some the "lanyard method" appeared as simple, and haphazard, as the displacement launcher seemed complex, and impractical. The lanyard method was held in abeyance until drop tests could be made to show what happened to a free-falling rocket dropping out of a turbulent body of air.

In the meantime it became clear that a displacement-type launcher would present many difficulties with certain aircraft, often requiring major structural changes in the aircraft itself. There was concern, too, that inaccuracy might result from sudden aircraft attitude changes in the interval between the release of the gear into the down position and the firing of the round. Ground tests had shown that there was a definite pitching down of the aircraft at the end of the gear's downward swing. Nevertheless, a decision was made to use this gear for the first air-firing test of the formidable Tiny Tim. This test was scheduled for June 22, 1944; Tom Pollock elected to be the pilot.

Pollock was the master of first firings. He fired the first forward-firing rockets for the Navy at Goldstone Lake on July 14, 1943. His subsequent firsts included the prototype CalTech 3.5-inch AR, the 5-inch AR, and the first aircraft spinner rockets developed by NOTS. As commander of AODU-1, he exercised his leadership prerogative by flying the initial tests on what he termed "radically new installations." When Pollock felt that the installation was satisfactory, he passed the project on to one of his pilots.

Thursday, June 22, 1944, must have been a busy day for NOTS in general and Lieutenant Commander Pollock in particular. There were many distinguished foreign visitors on board to witness the important test, including Lord Cherwell, Churchill's chief scientific



Distinguished visitors observe first Tiny Tim firing, July 1944. Left to right: Dr. W. A. Fowler, Captain S. F. Burroughs, Jr., Commander D. B. Young, Lord Cherwell, Lieutenant Colonel E. Boulton-King, and Dr. E. L. Ellis.

advisor, and Lieutenant Colonel E. Boulton-King of the British Army General Staff. The leadership of the Bureau of Ordnance and CalTech was well represented. Pollock later recalled, "...there was an awful lot of 'brass'...at least two captains, Chief of Naval Operations, and officers from Washington, BuAer, BuOrd and heaven knows what else, to observe this test." He also recalled his concern for the unknowns of this particular "first"—he wore a brand-new parachute.³¹

There were to be four separate flights of TBF-1 #01575 during the day, each flight carrying a Tiny Tim, whose size never failed to be the main point of discussion. The first two rockets were to be dropped inert to test the action of the displacement launcher; if this proved to be satisfactory, two further Tiny Tims were to be fired in flight. The entire test series was to be photographed by motion picture cameras carried by a companion aircraft.

For the team of ordnancemen who would load the big rockets on the TBF, it would be a long, and literally hot, summer day, compounded by the apprehension of a delayed schedule that might

subject the important visitors and Navy "brass" to undue broiling in the hot desert sun. Moreover, the ground handling of Tiny Tim had not yet reached a high level of expertise, and the Station logs of the time record many lacerations and pinched fingers as the consequences of unfamiliarity with constantly revised launching gear.

Despite Pollock's robust attitude toward rocket testing, he might have had things on his mind other than the imminent venture with an untried rocket of Tiny Tim's magnitude. Two days before the maiden flight for Tim, one of his pilots, Lieutenant Donald A. "Skinny" Innes, had died in his F6F-3 while diving onto a target in Salton Sea; a rocket had apparently exploded while still on its launcher. Pollock had flown immediately to Salton Sea and returned to NOTS without any specific knowledge as to the cause of the accident. Today, Thursday, while he was airborne and about to drop the first Tiny Tim, his office would receive a dispatch at 1045 that the body of Lieutenant Innes had been recovered.

The torpedo bomber soon reached its test altitude of 8,000 feet above the desert, and Pollock trimmed for level flight. He pressed the firing control, and the big rocket fell away smoothly. In this inert drop test, the displacement launcher had functioned perfectly.

The next drop test also went well. It would be the third test that would tell the story when the full force of the largest aircraft rocket of World War II would be unleashed.

Aloft for that critical third flight, Pollock leveled his TBF out at 10,000 feet and lined up with the bulldozer blade mark on C-1 Range far below. At 1230 he pressed the rocket firing switch. With a roar, the first air-launched Tiny Tim streaked away.

The exultation of Pollock and of the watchers on the ground can only be imagined. At last the potential of the "really big rocket" could be fully grasped. To the British observers, particularly, here was a possible weapon to knock out the launching sites of the German V-1 robot bomb that had struck London five days earlier.

The apparent success of the first air firing was quickly duplicated. In Pollock's words, borrowed from submariners' parlance, the second "shot went hot and true." But immediately after the firing he encountered sluggish controls. Ground inspection revealed that a large section of one elevator was missing.

This failure caused considerable concern. From that point on aircraft would be inspected both before and after firings of Tiny Tim. But whatever the cause of the structural failure, it did not dim the radiance of the success with the big rocket.

The radiance spread. Immediately following the tests, Fowler sent a telegram for Pollock to send to Lauritsen, who was in Washington on other rocket business:

HAVE THIS DAY GIVEN BIRTH TO TWIN TINY TIMS WITHOUT
ADVERSE EFFECT

(Signed) MOTHER POLLOCK

The next day, as soon as the motion picture film of the tests was processed, it was flown to Washington. Tiny Tim's success became immediately apparent at the highest levels of the Navy Department. The priorities assigned to Tiny Tim development by the Navy Chief of Staff presaged an even higher rate of activity for the busy desert Station, primarily in further launcher development for a host of Navy aircraft (TBM, SB2C, F6F, F4U). The Army Air Forces were also eager to have their A-26, an attack light bomber built by Douglas, fitted with a Tiny Tim launcher. And, although the air-launch feasibility had been verified, there was still a lot of work to be done on ballistics determination, fuzes, and a warhead suitable for underwater trajectory.

The manifest success of June 22 was not sustained over the ensuing three months. The problems centered on the displacement launcher. Of the service aircraft scheduled for launcher modification, only the TBF, TBM, and the F4U (a fast, powerful single-seat fighter aircraft developed by Chance Vought) proved to be really suitable. The Army's A-26, in particular, was obviously unsuitable, as tests revealed considerable blast damage to the elevators.

For other reasons, too, the CalTech-NOTS team was taking a second, hard look at the displacement launcher technique. For example, there was an interval of nearly one second between release of the launcher for its downward swing and the firing of the rocket. This delay was unconscionably long for a pilot to hold his sight rock-steady on target. Moreover, as had been anticipated, when the rocket and launcher slammed down into firing position, the aircraft pitched down violently, inducing a considerable sighting error at a most critical moment.

There was also the slight, but ubiquitous problem of structural damage to the elevators that manifested itself in many tests, ground- and air-fired. It was a problem encountered with different types of aircraft (for example, the A-26), and was one that quite obviously niggled the minds of CalTech and the Navy alike.

A consensus held that the blast of the big rocket's propellant was responsible, and that the solution lay in the proper separation

distance between the aircraft and the round as it fired, most thought that the length of the displacement launcher was insufficient.

Test followed test all kinds of tests to determine the exact nature of the rocket's blast, how it applied in an infinitely variable set of conditions, and its effect on aircraft structures. Ground tests involved aircraft suspended from massive cranes and perched on specially built ramps. Bone-tired engineers, ordnancemen, pilots, and scientists repeated a single test time after time whenever they felt they were getting close to solving the problem. Repeatedly they asked the questions, "What is the problem? What are we up against?" At worst, the problem was seen in a varying degree of damage to the plane's tail structure, sometimes, especially after air-launching a Tiny Tim, there was no damage at all. Many of the combat-toughened pilots of AODU-1 tended to view a few buckled ribs as trivial damage. Possibly Lieutenant Armitage was one of these.

Even as displacement launcher development was, quite literally, in full swing, the initially considered lanyard method of air-launching Tiny Tim was becoming increasingly attractive. Drop tests with inert rockets in early August 1944 affirmed that the drop attitude of the rocket would not be a significantly variable factor. These tests further affirmed that the rate and angle of free fall were uniform for any given airspeed and dive angle. From the test data it could be concluded that the use of a lanyard from the aircraft to fire the rocket should provide a reasonably accurate launch.

The aircraft selected for the "hot" air tests was an SB2C, and the first two Tiny Tims fired by the lanyard drop method on August 17 and 18 were successful. So was the third on August 21. But on the test of the fourth Tiny Tim on the same day, something went terribly wrong. At a flight altitude of 1,500 feet, the rocket dropped clear and the lanyard firing functioned perfectly as before at the proper displacement distance of approximately 3 feet below the aircraft. But as the horrified ground observers watched the big rocket ignite and speed away, the SB2C piloted by Armitage suddenly nosed over into a steep dive and crashed headlong into the desert floor.

Within minutes, the Assistant Flight Officer at Harvey Field, Lieutenant Floyd Hewitt, arrived at B-2 range in an NE-1* with a doctor as a passenger. Almost immediately, Pollock landed a second NE-1 near the crash. The scene was appalling. No semblance of an

* The NE-1 was the Navy version of the Piper "Cheshopex," a light observation and liaison monoplane whose short landing and take-off run and air lagoon tires made it ideal at Inyokern for quick trips out to the desert ranges.

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Crash scene of August 21, 1944. Lieutenant John M. Armitage was killed while test firing a Tiny Tim rocket from his SB2C aircraft.

aircraft could be detected in the twisted fragments bestrewing the desert sand.

Notwithstanding the tragic loss of a warm-natured, extremely likable young officer, whose early reporting date of December 21, 1943, made him a respected NOTS pioneer, there was an immediate question of grave concern: What had happened? On the schedule were numerous air launchings of Tiny Tim in order to meet the target date of November 1, 1944, for service testing. Were there more such tragedies ahead? The answer rested somewhere in the fire-blackened debris of what had been SB2C, Serial Number 18248.

As soon as the numbing shock lifted from the Station, activity continued. An entry in the Duty Officer's log for August 23, 1944, reads: "0820: Lieutenant Dibb took off on first operational flight of the day. Ammunition authorized to be fired includes 3.5-inch AR, 5.0-inch AR and HVAR." Tiny Tim would not be air-fired again for many weeks to come. Instead, there was a feverish burst of investigative activity, including the use of elaborate test setups with instrumentation for exact measurement of the forces exerted on the aircraft structure when the rocket was fired.

But the first real clue came by happenstance. A Navy chief petty officer photographer, on temporary assignment from the Hollywood office to make a training film, happened to get some footage of Armitage's plane from the moment the Tiny Tim was released and fired. When analyzed by CalTech's master of precision, Dr. Ira S. Bowen, this fortuitous piece of film revealed the tremendous negative *g* forces imposed on the SB2C as it nosed into the desert floor. Pollock describes the significance of this revelation:

It was a terrific force. Had Jack not been surprised by this, had he known it was coming, [with] his feet on the dashboard and both hands on the stick, it is doubtful if he could have held the plane from crashing into the ground . . . it *had* to be a "flipper"—something of terrific leverage.³²

The blackened wreckage yielded a further clue. This was one of the two trim-tabs fitted to the elevators. Dr. Emory Ellis, one of the original investigators, later elaborated:

In the design of the plane . . . they discovered that they had more trim-tab area than they needed, so they disconnected one; just simply fastened one permanently lined up smoothly with the surface of the airfoil, and let the other one serve as the balance tab which was activated from the cockpit. The job of fixing this other tab so that it wouldn't move was done with two metal clips—one at each end—and when the *shock wave from the ignition* of that rocket hit the tab it simply forced it out and then the points of the tin stuck and we found them that way. It just forced it beyond the strength of these two little pieces of tin that were holding the tab and then it wouldn't come back because it was jammed and of course that gave full down elevator, and down he went with an 8-g [push] out or something like that.³³

Ellis was quick to point out that no blame could be attached to the aircraft designers for the trim-tab fix, as it would have operated quite successfully under any normal conditions.

In the final analysis, the source of the tragic sequence was a shock wave caused by the igniter rather than by the propellant. The solution was now clear. Instead of the 1,200 grains of black powder originally used, it was found that one fifth of the quantity (235 grains) would do the job—without the shock wave. Moreover, the lanyard was lengthened for a greater separation distance between rocket and aircraft at the moment of ignition.

The death of Armitage had an effect far beyond the loss of a life and the failure of one test. The accident of August 21, 1944, marked a difference in the tone and pace of NOTS—CalTech operations. The feverish pitch of training, testing, reworking, and flying had pushed the rocket efforts to an unsustainable level. Henceforth, the pace would be more measured. Impatience would be tempered with more caution; risks would be better gauged against

potential advances; technical work would be viewed closer for its human implications. Why did the death of Armitage have this effect? In 1944 hundreds of thousands of young servicemen were dying in the wide arena of the war. Three fatalities had already been experienced by NOTS in the eight months it had existed.

The Armitage crash had not been the first. As previously mentioned, Lieutenant Innes had lost his life at Salton Sea on June 20, 1944, as the result of a rocket exploding under the wing of his F6F. Three days later, Lieutenant Douglas J. Walthall and his crewman Wilson M. Keller of Squadron VC-82, attached to NOTS for Fleet training, were killed under similar circumstances over the Inyokern range. Both of the tragic accidents were believed to be caused by improper rocket ordnance assembly; namely, the failure to install a base plug between propellant and warhead explosive.

Nor was the Armitage crash the last of the woeful series of losses in the summer of 1944. Only 8 days later, on August 29, Lieutenant Robert A. Dibb was flying an F6F Hellcat fighter on a rocket sight calibration test. He fired a 5-inch AR with an inert head at a ground target from 500 feet altitude. The rocket hit hard and ricocheted upwards into the path of the F6F, tearing off a wing; Dibb was killed instantly in the ensuing crash.

Each of these tragedies had its own special circumstance and meaning. But in none was the relationship between the lives of pilots and the responsibilities of weapon developers so dramatically portrayed as with Armitage. In this case it had been the difference between 235 and 1,200 grains of black powder. The fact that Armitage was a zestful youth whose impulsive, fun-loving ways had made him close to military and civilian alike intensified the message, as too did the circumstances of the test, occurring as it did at a dramatic moment in the test program when all eyes were focused on the scene of tragedy. The result was the intense realization that men's lives as well as military missions frequently depend on an exacting discipline, a regulation, a procedure, a small metal base plug, two little pieces of tin, or 1,000 grains of black powder.

The change of tone and pace that became evident in August 1944 cannot be attributed solely to the Armitage and other tragedies of that period. It was also part of a general maturing of the Station. The primitive environment was fading away behind newly constructed facilities. Answers once obtained by trial and error now came from data banks. There was a growing body of experience to draw from.

No longer was there a question as to the tactical value of rockets. Rockets tested and used in training at NOTS were proving their value in war, and there were even those who dared predict the end of guns as the primary armament of the Navy.

LATER WARTIME PROGRAMS

There is a hoary cliché that states, "One test is worth a thousand opinions." In the summer of 1944 the saying was bright and fresh and certainly applied to NOTS.

The test work so predominated the wartime activities at NOTS that there were some with serious doubts whether the research and development functions called out for the Station in the Secretary of the Navy's establishing order would materialize. It was certain that the test function was critical then and would continue to be so.

Although there were those who supported the research and development functions, the "test people" were strongly convinced that the Station's role should be limited to testing. No testimony supporting this viewpoint is more revealing than the statement by Rear Admiral W. A. Kitts, the self-styled "rocket czar," who also happened to be Deputy Chief of the Bureau of Ordnance:

This is a *test* station and if Captain Burroughs doesn't realize this, I will send out some 16-inch guns and make him test them out there on the desert, so that he will remember that this is a test station.³⁴

But no one pressed for a redefinition of the future role of NOTS. It was clear during the war that NOTS was primarily a test station, not only in name but in fact. Its biggest contribution to the war was through its rocket test work for CalTech, which was critical in bringing the new weapons into battle. But tests were not limited to rockets. Other significant work included testing of fire control systems for guns, incendiary bombs, machine-gun packages, proximity fuzes, and radar. And there was also testing not necessarily geared to any particular development hardware; for example, studies of aircraft vulnerability in a diving attack and "toss-delivery" techniques for air-launched weapons.

The number of Station projects for the war years was well over a thousand.³⁵ Of these, the emphasis toward the end of the period was on Holy Moses and Tiny Tim, two air-launched rockets. There was still a lot of work to be done on both of these rockets. The gulf between demonstrating the feasibility of any weapon and employing it under combat conditions is traditionally wide. Although the 3.5-inch

AR (predecessor of Holy Moses) and the 5-inch HVAR (Holy Moses) were in large-scale production and actually being used by the Fleet, they were not finished weapons in the sense that their performance could not be improved. There was also a need for better fuzes, more effective warheads, improved launchers and fire control, and, most important, accurate sighting devices. Many more thousands of the rockets would still have to be fired over the desert at Inyokern before these improvements could be realized.

Above all, the CalTech scientists needed data, especially ballistics information about the fundamental behavior of rockets: their trajectories, velocity, and dispersion under a host of varying launch conditions. Until this basic information was acquired, there could be no meaningful development of improved launchers and rocket sights. While hundreds of air firings were conducted under simulated combat conditions, a large proportion of the data testing was accomplished by use of specially developed equipment at the new NOTS ground ranges. This equipment took the form of fixed launchers capable of being set up at any desired angle and complex photo instrumentation to record the rocket's flight from launch to impact.

One of the "test tools" perfected during the latter part of 1944 is worthy of special mention as it pioneered the technique of supersonic rocket-sled testing used by NOTS in later years. The 200-foot launcher was modified so that the test round could be accelerated on its rail to aircraft velocity by "pusher" rockets. At the desired speed, the test round was ignited automatically and fired from a zero-length launcher mounted on the pusher-rocket assembly. The principal advantage of this high velocity booster, first tested in October 1944, lay in its capability for tests of fuzes and plate penetration at impact velocities hitherto obtainable only by forward firing from aircraft in flight. In addition to saving much precious flying time (and wear and tear on the men and machines of the Naval Air Facility), accuracy was improved by the high velocity booster over that of aircraft firing. Thus, it permitted the use of smaller targets with a higher percentage of hits.

The main thrust of the CalTech development work and the NOTS test work in the fall of 1944 was to complete the weapons under active development and get them into combat. This applied not only to the weapons themselves but also to the weapon support systems. One of the priorities was a launcher for Tiny Tim.

At 0800, on Thursday, October 5, 1944, an F4U-1D took off from Harvey Field with a Tiny Tim rocket aboard—the first to be

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air-fired since Lieutenant Armitage was killed a little more than six weeks earlier.

The six weeks had been productive; the Tiny Tim igniter problem had been solved. Now it was back to the business of solving the residual problem of launching the giant rocket.

Special emphasis was on the testing of the displacement launcher on the F4U. This priority was a natural result of the selection made in July of Marine Air Group 51, which flew F4Us, as the unit to be trained in the use of Tiny Tim against the European launching sites of V-1 flying bombs.

The Tiny Tim test on October 5, 1944, was successful, as were dozens of subsequent tests of the displacement launcher on the F4U. But this success was not matched with other aircraft. For some the structural modifications became staggering. For these aircraft the lanyard drop method was the obvious alternative, and eventually, even the F4U was included in the long list of aircraft that adopted this method.

In addition to this and other launcher work for the Navy, there was significant work on rocket launchers for the Army. Some of the launchers in use on Navy aircraft could not be mounted on Army aircraft because of decided differences in their wing structures.



Displacement launcher developed for Tiny Tim (F4U).

Brand-new launchers had to be designed. Much of the flight testing of the redesigned launchers was conducted by a new neighbor in the desert: the Flight Test Base, Muroc, California. This installation some 70 miles south of Inyokern was the genesis of what was later to become the huge Edwards Air Force Base—an important flight test center for supersonic and space flight development. During the war, however, it was only a field test facility for the Army's rocket program, which principally was centered at Wright Field, Ohio, and Dover Air Force Base, Delaware.

Next on the list of program priorities was rocket sights. Ironically, in the early days of the forward-firing rocket program, little regard was paid to sighting devices for the new weapons. It was apparently considered that the gun platform philosophy of attack aircraft applied equally to rockets as to machine guns: all the pilot had to do was point the aircraft at the target and shoot. Tom Pollock recalled that his first rocket sight was a small pointed piece of adhesive tape on his windshield, positioned as the result of observing the trajectories of a rocket fired from the aircraft on the ground at Goldstone Lake.

Soon, the Bureau of Ordnance's excellent Illuminated Sight Mark 8—developed for fixed, forward-firing machine guns in 1941—was modified for rocket use. This was done by adding an adjustable reflector that permitted the line of sight to be raised to compensate for the rocket's greater gravity drop. The main objection to this expedient stemmed, not from inaccuracy, but from the addition of one more manual task to the many already facing pilots. In mid-1944 the Bureau met that objection by replacing the adjustable reflector by a sight whose reticle had a vertical ladder of crossbars that allowed the pilot's eye to raise or lower his line of sight. Of course the pilot had to be familiar enough with the different rocket types to select a particular line on the crossbar. Accordingly, pilots needed sighting tables that would indicate the necessary sighting information for a particular plane, rocket, airspeed, dive angle, and slant range.

The CalTech scientists working with Navy pilots and range officers undertook the job of collecting range data from rocket firings and reducing them to tabular form. In the process thousands of aircraft rockets were fired on the NOTS ranges. And as Burchard, the OSRD historian, points out, "the editorial section of the California Institute group worked under forced draft to get the results into print and the tables started on their way to the fighting fronts."³⁶

As the war progressed, it became apparent that the accuracy of forward-firing rockets could stand a lot of improvement. The Bureau was already working hard to enhance the accuracy of fixed machine guns with a sophisticated system of fire control. The result late in the war was a gyroscopic lead computing gunsight—the Gun Sight Mark 23—that was almost completely automatic. All the pilot had to do was keep a constant sight on his target and control an expandable circle of dots to continually embrace the target's wingspan (a rotatable knob on the throttle handle was used).

But where a mass volume of fire from multiple fixed machine guns usually compensated for any pilot sighting inaccuracy, the same was not true for individual rocket projectiles. Moreover, the flight characteristics for conventional ammunition were well-known; those for rockets were not. Had they been, there would have been fewer problems in modifying the Gun Sight Mark 23 for rocket use. This was done eventually, but it was not ready for operational use until late in the war.

In the meantime, CalTech became entrenched in the rocket sight development business, applying their specialized expertise and amassed data toward the design of a rocket sight.

During the last year of the war, CalTech developed four such sights; each was designated "CIT Aircraft Rocket Sight" and was given a type number (1 through 4). A noted astronomer, Dr. Horace W. Babcock (later Head of Hale Observatories), developed the first CalTech rocket sight. Thousands of rockets were fired at NOTS in testing these sights. On the first test of the CalTech Type 1 sight on June 4, 1944, the test pilots were reportedly enthusiastic.³⁷

The Type 1 sight never went into service use because Type 2, following hard upon its heels, offered improvements. It had a two-way throw switch that enabled the pilot to select either of two kinds of rocket ammunition, even after he had started his diving attack. Neither Type 1 nor Type 2 was a completely automatic sight. The pilot had to set dials in advance for predicted airspeed and propellant temperature; he also had to make his diving attack at a predetermined angle. However, the changes in altitude, automatically fed into the sight from a barometric altimeter, continuously readjusted the sight and permitted the pilot to fire at any point within the effective range of his rockets. These early rocket sights, while crude by modern standards, represented a large step toward freeing the pilots from what some termed "worries."

In addition to a whole catalog of weapon projects—Holy Moses, Tiny Tim, rocket sights and launchers—CalTech managed to include yet another one in that exceedingly busy year 1944: aircraft spinner rockets.

The technique of stabilizing the flight of ground-launched rockets by spinning them—in much the same way as rifle bullets and artillery shells—was recognized quite early in U.S. rocket work. A principal advantage of “spinners,” as they were called, was that of size. Finned rockets need considerable length in proportion to their diameter for stable flight characteristics; spinners can be much shorter. For example, the 5-inch finned aircraft rocket was 69 inches long, while a barrage spinner of the same diameter was only about 32 inches long. Moreover, as the spinner’s rotation is derived by directing the exit thrust gases through canted exhaust nozzles, its external configuration is veritably that of a conventional projectile. Consequently, the rocket can be launched from a tube. The absence of protruding fins also greatly simplifies storage, transportation, and handling. In view of these desirable characteristics, it is not surprising that the ground-deployed barrage spinner rocket became a prime candidate for aircraft application.

No active program for spin-stabilized rocket development existed until 1943 when CalTech and Section H of OSRD had independently started investigations. The first exploratory work on spinners at CalTech had taken definite form with a request from the Marine Corps for a spinner that might replace the 75-millimeter pack howitzer. The objective was to give ground troops lighter and more portable weapons with significant striking power against point targets. A 3.5-inch spinner rocket was developed; however, it was not significantly superior to the howitzer it was designed to replace, and hence never saw service use.

The next member of CalTech’s spinner family was the 5-inch high velocity spinner rocket (HVSR) developed to give PT boats greater firepower, particularly against Japanese armored barges sent to supply and reinforce their island garrisons. The 4.5-inch barrage rocket (fin-stabilized) had been used to some extent for this task, but it was far from ideal because of low velocity and large dispersion.

The first sea tests of the HVSR, held at Terminal Island in San Pedro Bay off Los Angeles in the summer of 1944, were plagued with difficulties. However, despite these initial problems, the 5-inch HVSRs proved to be capable performers, and the Bureau of Ordnance

initiated extensive procurement of launchers and rockets. Although the rockets were originally intended for use by LCVP (landing craft, vehicle and personnel) and LCM (landing craft, medium) vessels, and even for jeeps, simultaneously with the development of the 5-inch spin-stabilized barrage rocket, the Navy began development of a rocket gunboat specifically designed for its use; a design that featured continuously reloadable rocket launchers.

Initially, three versions of HVSR were planned, each with a different range: 5,000, 2,500, and 1,250 yards; however, it was the type with a high-capacity head and a 5,000-yard range that was completed first and rushed into service use. This rocket ultimately distinguished itself in support of the troops hitting the beaches at Iwo Jima and Okinawa.

In experimenting with forward-firing spinners, the rocket designers also took into account the seemingly greater advantages of fin stabilization for aircraft rockets—highly effective under air-launch conditions when the rockets had a considerable forward velocity even before they left the launcher rail.

There was also an early recognition by the United States of a basic problem inherent to the use of spinners as aircraft rockets; a problem that essentially centered on installation of fixed tubular launchers on high-performance aircraft. These launchers reduced airspeed and impaired aircraft maneuverability. A major significant program for NOTS during the last year of the war was to solve this problem and subsequently to develop a successful spinner aircraft rocket.

Unlike Holy Moses and Tiny Tim, CalTech's aircraft spinner rockets never acquired fanciful nicknames. Instead, they fell prey to a mundane, although complex, system of rocket designations. A glimpse at the list shows the broad range of use for the family of spinners under development.

Surface-fired spin-stabilized rockets:

- HCSR for high capacity (medium shell thickness, maximum HE),
- GPSR for general purposes (thick shell, HE),
- CnSR for common (semi-armor-piercing, HE),
- SmSR for smoke (thin shell, FS or WP smoke),
- CWSR for chemical warfare (thin shell, chemical agents), and
- PySR for pyrotechnic (illuminating flare).

Air-fired spinner rockets:

- CASR for common,

GASR for general purpose, and
PASR for pyrotechnic.³⁸

Ironically, one of the uses first contemplated for aircraft spinners in the United States was a simplistic reminder of the first use of an aircraft-fired rocket; that is, a rocket fired backward, or "retrofired." But where the MAD retro-weapon was a rocket-decelerated device whose net result was a vertically falling antisubmarine weapon, this early aircraft spinner rocket was to be fired backwards from the tail turret of a bomber against pursuing fighters. This was a real need as the latest German Messerschmitt 252 jet fighters, armed with heavy nose guns, were attacking our bomber formations from astern beyond the protective range of the tail gunner's 50-caliber machine guns.

Unfortunately the CalTech development of the retrofiring aircraft spinner did not provide a solution. Tests at NOTS showed dispersion in retrofirings to be very high, and the spinner behavior was erratic; hence development was not completed.³⁹ From the evidence available, it seems that NOTS attempted to design and install a turret launcher on a B-25 aircraft. Lieutenant Eugene A. ("Gene") Valencia was the project pilot. Similarly, Dr. Babcock was thinking in terms of a tail launcher for use in B-17 and B-24 bombers as defensive armament. Some testing of an experimental tail-turret launcher (designated X2R-1) was conducted early in 1944. But the priorities for backward-firing spinners gave way to the greater need for forward-firing aircraft spinners.

The first forward-firing aircraft spinners tested at Inyokern were fired from an F6F-3 aircraft on October 7, 1944; the aircraft was in a three-point attitude on the ground. Launcher tubes made of 4-foot lengths of 6-inch-diameter steel pipes were attached to the fighter's wings in place of the more conventional zero-length launchers.

Eight rounds were fired in this first ground test. Visual inspection revealed no damage to the aircraft, except some small dents, and the launcher itself was undamaged. More importantly, the rocket's flight appeared to be reasonably true, with a final dispersion that, although greater than that of fin-stabilized rockets, was not unduly large. This was not the case three days later, on October 10, when it was decided to test the aircraft spinner in flight. Pollock recalls that his launch aircraft used for this test was a PV-1.

It would be an understatement to describe the results of the first air test as "disappointing." They couldn't have been worse. Even the usually imperturbable CalTech report writer found it difficult to mitigate the spinners' wretched performance: "... the rounds left the

aircraft in a wide spiral which increased in diameter, finally reaching a diameter of 50 feet . . . at the end of burning, every round began to tumble, rotating in a vertical plane . . . dispersion along range was observed to be large (from 300 to 600 feet) . . . lateral dispersion (400 to 500 feet) . . . several rounds were observed to cartwheel along the ground for varying distances up to 400 feet."⁴⁰ It was devastatingly clear that forward-firing aircraft spinners represented a brand-new ball game.

CalTech scientists knew a lot about rocket ballistics. They had acquired enormous volumes of data, and had, in fact, "written the book" about the subject. But aircraft spinners were radically different from fin-stabilized rockets; a new book would have to be written.

Burchard describes spinner development as "probably the most complicated project which the California Institute group undertook."⁴¹ The CalTech group investigating the erratic behavior of spinners was headed by Clarence Weinland. It became known locally as "the Spinner Society." Equally unofficial was the NOTS nickname bestowed upon the spinner: "Willie's Whirling Wocket" (for W. A. Fowler). The true complexity of the spinners was fully realized when the investigators began to confront all the interacting variables that could adversely affect its flight when launched from the air: dynamic flight forces imposed by the launch aircraft, the length and relative axis position of the launcher tube, spin rate of the rocket, the rocket's aerodynamic state of balance, and even a critical wind effect.

In order to understand, measure, and design for these and other variables, the business of collecting observed information would require additional thousands of air firings on the NOTS calibrated ranges. It would also require new methodology and new instrumentation devices; specifically, a device that could record a spinner rocket's flight from launch to impact, as seen from the rocket's point of view. Dr. Ira Bowen, working with an idea of another CalTech scientist, W. R. Smythe, developed such a device and called it a "solar yaw camera."

This instrument, essentially a pinhole camera, was mounted as the nose section of a spinner rocket and began operating as the rocket fired. The rotational movement advanced a film strip continuously past the light-admitting aperture, realizing one exposure for each rotation. The angle of the sun's rays striking the film produced lines of varying lengths. Analysis of these lines resulted in complete position information about the rocket at any moment during its flight. Thus, the solar yaw camera made it possible to



Courtesy Millikan Library, California Institute of Technology

Dr. Ira S. Bowen, Professor of Physics at the California Institute of Technology, and inventive genius for rocket test instrumentation.

establish a base line of data for a particular round's shape and balance, and when augmented by known trajectory information, enabled a determination of aerodynamic forces during and after burning.

New instrumentation and experimental techniques helped solve many of the spinner's problems to such an extent that by the end of the war, a forward-fired 5-inch spinner would be developed that was at least as accurate as the best of the forward-fired fin-stabilized rockets under certain conditions. But many problems would remain unsolved. Prime among these was the old familiar ogre of rocket development--launchers.

In its simplest terms, a spinner launcher was just a tube, like a gun barrel that could be hung on conventional pylons or ordnance racks underneath a wing or fuselage. But the new breed of aircraft were not being designed for such appendages. These were the jet aircraft that were beginning to emerge: aircraft that were highly dependent upon a smooth aerodynamic configuration for maximum performance. Concerning the effect of externally mounted ordnance, it may be recalled that the first 70-inch launcher rails reduced the airspeed of the redoubtable old TBF by many knots. The answer, of course, would be to mount the tubes internally, either in the wing or fuselage. But this solution implied almost a total redesign of the aircraft structure, and the practicability of this rested in the future.

But what of the future? There were many who pondered it in the last months of 1944 as they contemplated a new year--America's fourth year of war.

Ostensibly, the war was going well, and there was a new confidence in the American fighting man and his weaponry as the offensive was pressed with new vigor in both theaters.

Following the spring landing in Normandy and the subsequent landing in the French Mediterranean, the Allied Forces were on the Continent in massive numbers ready for their drives into Germany. Heavy aerial bombardment aimed at Germany's industrial heart was gathering ever more momentum.

The progress of the naval war, too, was realizing success after success for the U.S. Navy as the favorable tide of battle pressed irrevocably toward the Japanese homeland. Victories at Saipan, Guam, and the Battle of the Philippine Sea, which marked the end of Japanese carrier power in the Pacific, presaged the inevitable outcome of the long hard conflict.

FLOOD CURRENTS IN ROCKETRY

And in the theaters of war there was a burgeoning recognition of the importance of rocketry in the campaigns to come.

At NOTS Inyokern, there was also concern for the future of military rockets after the war. Much of this concern was focused on the survivability of the desert Station in the postwar years as a center for the further development of rockets and research leading to other advanced weapons. Most recognized that a key factor in any such speculation was the planning and quality vested in the construction of facilities—test ranges, workshops, laboratory, and a community.

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4

Boomtime Construction

Although construction was second in priority to operations, there was nothing secondary about the wartime construction accomplishment of NOTS, particularly the spectacular growth of the first year. Homesteaders who had struggled for years under difficult conditions to build meager homes and dig wells regarded it as a miracle of the desert. Where there had been little but creosote bushes, tumbleweeds, and sand, the progress of a few months revealed a sprawling station with hundreds of buildings and facilities under construction—test ranges, launchers, instrument stations, and utilities; and a brand-new town beginning to be carved out of the desert.

The wartime construction of NOTS embraced three distinct phases: the initial planning and erection of temporary facilities, the construction thrust of calendar year 1944 when most of the temporary and permanent facilities were built, and the last phase comprising a wind-down at the end of the war. Phase 1 was covered in an earlier chapter; the focus here is on Phase 2, which outstripped all subsequent construction eras in the history of NOTS.

PERMANENT VERSUS TEMPORARY STRUCTURES

As the United States took the offensive in the European and the Pacific Theaters, thinking also shifted more toward the future peacetime Navy and long-range ordnance needs. Officers who had witnessed the nation's traditional peacetime disinterest in ordnance

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experimental facilities were prone to consider the moral of the Three Little Pigs, and the differences between houses of straw and stone. Consequently, in respect to NOTS, there was a decided shift toward building permanent structures, and stubborn resistance began setting in toward starting any more temporary buildings than were absolutely essential. Byrnes and Burroughs led this shift.

As noted previously, Burroughs progressively came to regard the new Station as an "American Peenemünde." Military reports were being received of Germany's secret rocket base where the formidable V-2 rockets were being developed. Burroughs later described his conviction that the United States needed an equivalent to Peenemünde, "where you could build, design, develop weapons in secret so that nobody knows what the hell you're doing . . . [we] felt that we needed the whole laboratory, the shops and the tools to do the whole job there because you can't farm things out if you are going to keep things quiet."¹

But the new emphasis on permanent structures ran counter to another new trend, concern over rising costs. It was inevitable that the specter of cost would rise to haunt the planners and builders of NOTS and pose the first real threat to the realization of a permanent Navy research and development center. Shortly after Captain O. A. Sandquist took over as the Officer in Charge of Construction, the first realistic cost estimates were appearing: stark indicators to point out the differences between temporary and permanent structures, and the fiscal consequences of constantly revising a wish list.

Of course, the \$160,000 "Navy Vessels" money initially committed by the Bureau of Ordnance to start the ball rolling was patently a token payment. However, it was generally acknowledged that the \$9,500,000 obtained for the Station through the Public Works Appropriation Bill (passed at the end of 1943) was quite a respectable sum. Yet, even as the Secretary of the Navy released these funds to the Bureau of Yards and Docks (February 1, 1944), the estimated costs of the approved facilities had already reached more than \$22,000,000—considerably more than double the congressional appropriation.

The problem of the deficiency being greater than the authorized funds was further compounded by Burroughs, Sandquist, and the CalTech scientists who kept adding requirements as their on-site perspective and reports of rocket usage in the war gave them a fuller comprehension of the needs. The Bureau of Yards and Docks reported on January 27, 1944, that the "facilities submitted by the

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Field" represented an increase in the scope and, if approved, would bring the total cost up to \$23,739,473 and the deficiency to more than \$14,000,000. In view of this, the Bureau felt it did not appear "advisable from a planning standpoint to proceed with permanent construction until the scope of the work had been defined."²

As the \$9,500,000 appropriation was sufficient for the wartime facilities and a permanent research and development establishment of limited scope, the brunt of the question was whether or not the Bureau of Ordnance had the determination and the resources to go ahead with its plans for an uncompromised, complete, and permanent R&D center. The new Chief of the Bureau of Ordnance, Rear Admiral George Hussey, following a brief visit to the Station in the midst of a howling sandstorm,³ reaffirmed the decision to go ahead as originally planned. He instructed the Bureau of Yards and Docks to proceed with the particular construction that could be accommodated within the available \$9,500,000 and declared that the Bureau of Ordnance would separately sponsor the remainder of the project. Hussey honored his commitment to aid in the sponsorship of NOTS. On April 18, 1944, he wrote to the Chief of Naval Operations requesting \$14,206,217 for Inyokern. Hussey's suggestion was to add \$7,750,000 to the 1945 Public Works Appropriation Bill, and use \$6,456,217 from Bureau-sponsored funds in the 1944 Supplemental Public Works Appropriation Bill, "...available after provision for Bureau of Ordnance contemplated construction projects and a reasonable allowance for unforeseen projects during the remainder of the fiscal year."⁴

On February 24, 1944, a letter of intent was issued by the Bureau of Yards and Docks for a cost-plus-fixed-fee contract with a combination of construction firms for what would be the principal contract for construction of the Station's permanent facilities. Contract NOy-9088 was a flexible agreement between the Navy and the combined firms of Macco Construction Company, E. S. McKittrick, and Morrison-Knudsen, Inc. Official approval of the contract would be forthcoming later, but work started immediately with the letter of intent.

A second contract, NOy-9048, was let in the same period to the group of Stafford, Davies, and Gogerty (mentioned earlier), for architectural and engineering services pertaining to all construction improvements.

Twenty-two years later Sandquist credited much of the rapid progress of the wartime building to the arrangement whereby selected

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contractors were able to work on a fee that was based on the percentage of the total costs and renegotiated at major stages. According to Sandquist, the Station could not have been built under the kind of competitive bidding followed after the war.⁵

One of the most significant impediments to building encountered by Sandquist in the early days at NOTS was the same one his predecessor, Captain A. K. Fogg, had experienced: nobody can build from vague requirements. Firm plans, duly approved and signed off, were necessary. For the NOTS laboratory, these were not immediately forthcoming.

DESIGN PROBLEMS

When the committee of Bureau of Yards and Docks designers and the NOTS Laboratory Officer, James Duncan, returned from their tour of the nation's laboratories, they made their proposal to the Bureau of Ordnance for not one laboratory but a number of them. If the Bureau wanted to do the many kinds of research that were being done in the laboratories visited, the committee would recommend "a laboratory for physics, a laboratory for chemistry, a laboratory for electronics, a laboratory for electrical engineering, a laboratory for metallurgy, a laboratory for plastics, and a laboratory for explosives." The committee further proposed that each laboratory building be "separate and distinct...spaced far enough apart so that no work being done in any one of them could interfere with work being done in any other."⁶

The Bureau of Ordnance took a hard look at the overall proposal and at once eliminated the plastics laboratory. This decision was based on the fact that existing facilities could take care of the Bureau's needs in plastics research. They also decided that the explosives laboratory should be located at some safer distance away from the main laboratory complex and later dropped the explosives laboratory. After many discussions with the Bureau of Yards and Docks, a complex of six separate laboratories was agreed upon; they were to be devoted to physics, chemistry, electronics, electrical engineering, and metallurgy, with one for general use.

Next, the Bureau of Ordnance scrutinized the laboratory layout that was part of the proposal and saw the buildings arranged concentrically about a central facility connected by long passageways like the spokes of a wheel; the passageways were to be open but

protected from the sun by a light roof. Duncan and some Bureau planners had something to say about this design, as they had recently returned from Inyokern and had experienced firsthand one of the Mojave Desert's environmental spring specialties—a howling, sand-packed windstorm. Understandably, they were disturbed by the prospect of walking at the mercy of such elements in the open passageways between the laboratories. Accordingly, the layout was changed to an arrangement of six wings extended from a long central corridor, three on a side.

Interestingly, the same “wheel-spoke” designer from the Bureau of Yards and Docks appears to have drawn the original layout for both the permanent Administration Building and the Station Dispensary. A more conventional layout was adopted for the Administration Building about the same time as the one for the laboratories. The proposed Station Dispensary layout, however, was changed when the NOTS Senior Medical Officer, Commander M. George Henry, vociferously conveyed deep emotions “that my patients would die of pneumonia on the way from my surgery to their ward bed unless they closed in the long connecting corridors to protect from the cold wind.”⁷

In the original Bureau of Yards and Docks proposal, each of the individual wings in the main laboratory was a different size, determined from the average amount of space devoted to a particular discipline in the laboratories that were visited. Since this size determination was entirely arbitrary, and since it was impossible to forecast the relative importance of the various types of research to be done at NOTS, the Bureau of Ordnance requested Yards and Docks to design all wings approximately the same size. Moreover, it was decided to make them more or less interchangeable except for the chemistry and metallurgy facilities. It was felt that the special needs of those (in terms of chemical benches, hoods, and furnaces) were sufficiently specialized to make definite selection of the wings in advance.

But the decision to make all wings the same size fell short of stating exactly what that size should be. Not even Byrnes could answer this one, and in one of his internal memorandums to the Bureau of Ordnance's Director of Research (Captain William M. Moses) on March 23, 1944, he wrote:

It is the opinion of Ad3 that is next to impossible to accurately compute what should be the physical : of the laboratory at Inyokern that will satisfactorily meet the future needs . the Bureau.⁸

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In the same memorandum, Byrnes acknowledged the usefulness of the "reliable data" obtained by Duncan and representatives of the Bureau of Yards and Docks in their inspection tour of the nation's leading laboratories. He continued by saying that the data would be used to "develop the Inyokern Laboratory to 'spread eagle' all sciences by its general arrangement [and] approximate sizes of the various scientific divisions and services."

But apart from discussing the relative sizes of comparable laboratories, the Byrnes memorandum is interesting because it reveals a general philosophy regarding the laboratory and a reason for careful planning at this early stage of the game:

Supplemental to the consideration of the adequacy of the laboratory in size, facilities, and arrangement for meeting the Navy needs, there is the further consideration that there will be little hope of attracting to the laboratory scientists of adequate stature if the laboratory is mediocre. With emphasis after the war on developments catering to civil peacetime needs, it is going to be difficult enough to get the proper men but with a mediocre laboratory, it will be impossible.⁹

But the considered detriment of a "mediocre" laboratory in attracting top-flight technical and scientific personnel was not the only cloud on the horizon. Where would they and their families live and play? What about schools for their children, churches, shopping facilities? Some answers to these questions were evolving in a modest Quonset hut at China Lake.

COMMAND POST

The second temporary NOTS headquarters building shared one of the unusual qualities of its predecessor at Harvey Field as it provided both office and living quarters. These were shared by Burroughs and his new Executive Officer John Richmond. Office furniture consisted of a desk, a long, low table for reviewing plans, and a group of chairs and a coffee table in one corner for conferences. The rear of the hut was partitioned into small areas for a mail-order shower stall and washroom. Heating was provided by one heater in the center of the hut. The hut was strategically located, as the Officer in Charge of Construction had a similar hut only a half block away that comprised his quarters and an office for the drafting section. Building plans were drafted in Sandquist's hut and then taken to the Burroughs-Richmond hut for review and approval. For most of the facilities, this was all the approval needed; so it was a quick step from design to construction.

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First Headquarters buildings at NOTS, China Lake, circa April 1944.

These were but two of about 60 Quonset huts eventually sited in the first temporary headquarters area on what is now Halsey Avenue. The plan was to operate from this area during the main construction period until the permanent Administration Building and the first quarters for senior officers were completed.

Some of the other structures that went up in the temporary area included a large water tower, a sprawling ship's service including the "Desert General Store," a first-aid building, a photography hut, a mess hall, 13 barracks, a temporary administration building for the Navy and CalTech, and an administration building for Navy construction and contract personnel.

Although the pressures were great to realize immediate goals at the possible expense of long-range planning, adherence to certain basic principles allowed a semblance of order in the construction. The temporary headquarters and the construction camp were located away from the permanent headquarters and housing areas. Also, Burroughs resisted all attempts to develop housing outside of the planned central community. Areas of open land were planned to be preserved within the housing areas to minimize the hazard of fire, and to give space for future expansion. Similarly, space corridors were kept between the Station community and the outside community for future flexibility; a bit of far-sighted planning that paid dividends in the future development of Burroughs High School, Pierce Elementary School,

two separate housing developments, a shopping center, and a community park. All major permanent business, social, and headquarters facilities were planned along a central street that is now Blandy Avenue. And the local command was exerting all the influence it could for permanent structures.

Despite the chaotic appearance of the construction work going on outside the headquarters hut, the plans being prepared inside held promise of better days to come. Unlike the early Indians, explorers, and prospectors who drank at Indian Wells and then pushed on, the naval officers in the small Quonset hut were laying the foundations for the Navy's permanent stay in Indian Wells Valley.

SOME CONSTRUCTION HIGHLIGHTS

A "nail-by-nail" description of the building of NOTS would be ponderous. However, a few construction aspects are appropriate to provide the perspective necessary to understand this period of NOTS history.

Burroughs once commented that the first mistake at NOTS was in starting construction by scraping off the bushes from large plots of land on the windward side of the community. With the ground cover gone, there was an unlimited supply of loose ground with which the desert wind could sandblast structures, automobiles, and people. The stories of early sandstorms are legendary. The old-timers called it "termination weather!" As one stated, "Due to so much of the desert being torn up, when the wind would blow, which it almost always did towards the end of the week, men would come into the office in droves to terminate, after working just a few weeks."¹⁰ Another postulated, "It seems the wind blew much harder during the early times of NOTS... the wind would pick up from the bare ground tons of sand to throw at us. At times [it] blew so hard and long we got so used to leaning against the wind... that if it had stopped suddenly, many people would have fallen flat on their back or face depending on which way they were trying to go."¹¹ While the retrospect of a quarter century tends to soften the recollection of "termination weather," to some the memory is still harsh. "When the wind blew hard, it was like a blast furnace with sand, or an ice flow with sand." Women employees had to wear slacks "to avoid being cut up on the legs by sand."

A second source of early-day irritation was the endless maze of open ditches. In one progress report on the steam and hot water

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Typical construction at NOTS showing one of many inconveniences the open trench!

distribution work, for example, there were 34,424 feet of trench opened in the same period that 11,889 feet of pipe were laid. The open trenches greatly interfered with other operations, as well as aggravating the blowing of loose sand.¹²

Three batching plants were set up to supply the transit mixers for the tons of cement that went into the building of the Station. Loose cement was received in bulk over a railroad spur from Inyokern specially built by the Navajo Indians. It was also brought in by tank trucks and stored in large silos.

To supply electrical power for construction, a special substation was set up by the California Electric Power Company near the Station's west gate. Temporary power lines were strung throughout the construction area in networks that frequently resembled spider webs in respect to their amount, but without the logical and aesthetic symmetry of arachnid design.

At ranches taken over by the Station there were water wells. Some produced potable water; others produced water only fit for construction use. There was a constant problem of having to truck water to various areas on the Station, and this was relieved only slightly by laying 5-inch steel pipes on the surface for distribution. To supplement water from the wells, a 6-inch-pipe connection was made

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to the Los Angeles aqueduct some 12 miles from China Lake. A major problem was the Station's early lack of sewage disposal facilities. In time a sewer system was developed, but portable privies dotting the landscape were the main solution.¹³

There were a few existing roads, but none was adequate for the upsurge of traffic. New roads had to be built. A large asphalt plant was set up and a pit was dug west of the main gate to supply materials for the roads.

At the beginning, the only telephone line connecting NOTS with the outside world was a private one that the electric company strung on an abandoned power line. The end instrument was located in the general store in Inyokern, and even a key person like Emory Ellis had to wait hours to make a call to CalTech. The single line was augmented by the addition of an army field-telephone system on the same poles. And late in the construction period another line was put in along the railroad.

The remoteness of the Station from any large labor source, together with the magnitude of the construction task, imposed the immediate problem of shelter not only for the Navy and CalTech personnel but also for the construction workers numbering up to 7,200. To accommodate them, one of the first undertakings was to build a construction camp; a small city consisting of 162 bunk houses, 39 latrine buildings, 9 barracks for foremen and engineers, 14 Quonset huts, 2 large warehouses, 2 mess hall buildings, 5 recreation buildings, 1 open air theater, and a boxing ring. The combined housing and messing facilities of the construction camp and the temporary headquarters, when completed, were adequate to accommodate the burgeoning population of China Lake. In October 1944, not quite a year after the founding of the Station, the population was approximately 8,000.¹⁴

THE LABOR FORCE

The most perplexing problem for the construction contractors was recruitment of labor; and having induced workers to come to a remote desert area, further inducing them to stay.

Military personnel reported to the Station under orders and generally accepted the untamed environment as just one of many varied fortunes (or misfortunes) of service life. CalTech personnel were generally a highly motivated group of professionals prepared to

serve wherever they could most benefit the war effort; however, there were even some among them who resisted Inyokern duty. But the big problem was with the large number of the laborers required to physically build NOTS. Under conditions of a national labor scarcity, the average laborer readily felt he could serve the war effort quite as patriotically in the metropolitan areas without taking on the uncomfortable role of a pioneer opening up a frontier. There was a patent need for special incentives, a fact that was clearly recognized by the local NOTS command, the Bureau of Ordnance, and the Bureau of Yards and Docks, but not by those who were in a position to set national priorities.

The Chief of the Bureau of Ordnance requested that the Bureau of Yards and Docks obtain a class "A" labor priority rating. Although this special priority rating was not obtainable, the Bureau of Yards and Docks assigned the best priority it could within its own programs.

Lack of a class "A" national priority was not the only reason for the NOTS labor problem. Although the Station was 150 miles from Los Angeles and in the totally different geographic environment of an undeveloped desert frontier, it was officially classified as being within the labor recruiting area of that city. Los Angeles, however, with a host of active defense plants that offered lucrative jobs in an attractive metropolitan area, was naturally one of the poorest recruiting fields in the nation. Failure to get labor for NOTS from this area necessitated a large "vigorous recruitment program" on a nationwide basis. While the recruitment rate of this program was satisfactory, it was so largely because it provided a means for many workers with families to have their travel expenses paid to California. All they had to do was report at the job site and begin work. Thereafter, there was no legal way to ensure that they remained on the job.

It is interesting to note that no special inducements were offered for work at NOTS except for a few selected skilled tradesmen who received free meals and lodging. The absence of any kind of living accommodation for families, other than off-Station trailer camps, was just one additional reason why most potential recruits preferred working in the metropolitan area. It also helps to explain why the construction contracts operated well below the established personnel ceiling most of the time.

An early unpublished history of NOTS by Lieutenant Robert W. Leach describes the early labor as being "deficient both as to quality and quantity."

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Concerning *quantity*, progress reports for the main NOTS construction contract (NOy-9088) show that by October 1, 1944, more than 6,500 people were at work; by December 15, the figure had risen to 7,200.

Absenteeism was especially bad before or after the weekend break; many would leave work a day or two early, and others would fail to return on Monday. At times this necessitated a hasty reorganization of work gangs. Also, many contractors operated on a schedule of "twelve days work—two days off"; this made for incredible "binges" on the two days off, incapacitating a large percentage of the work force.

The clearest indication of the magnitude of the labor problem was the ratio of hirals to persons actually on the job. Although there were never more than 7,200 on the job at any one time, more than 24,000 persons were hired within one eight-month period.

As to the *quality* of the labor, the early historian said it was "considered to be only poor to fair." He reported that very little local labor was available and the labor imported from outside had been "fairly well screened as to quality." Unfortunately, the NOTS contractor received what was on the coarse side of the sieve.

Wartime conditions and remoteness of the location cannot be used as an excuse for all the labor shortcomings. The recruitment program itself laid the seeds for many problems. For example, conditions at NOTS were flagrantly misrepresented to prospective construction workers. Leach gives an example wherein the name China Lake (from the dry desert playa) was misused.¹⁵

One man arrived at Inyokern with his fishing boat which he had brought all the way from Pennsylvania. He had been told that there was excellent fishing in the vicinity. He had been brought at government expense, but he stayed less than one week. Another man from the middle west arrived with the understanding that he would be able to commute daily from Pasadena, where he had planned to live with relatives.

Leach comments further

These are not isolated cases. Literally hundreds arrived expecting to live in a lush, green well irrigated valley, complete with Southern California's much touted sunny weather. Consequently, they were appalled at the conditions that met their eye in the bleak, dusty desert of the Indian Wells Valley.

Quite naturally they left almost as fast as they arrived to take more attractive jobs in the aircraft industry or the shipyards. They felt no compunction about leaving in spite of the free government transportation they had received. As a matter of fact, most of them left disgusted, and with a feeling that they had been cheated.

According to Leach, another serious fault of the recruiting program lay in the fact that no physical examination was required. He reports:

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...prospective employees arrived in all conditions of physical distress. Venereal disease and pulmonary disorders were especially common. Some arrived barely able to walk through the main gate under their own power. This, naturally, created a terrific social problem, which was never solved and continues even today [1945].

Concomitant with the hiring problem was that of security. Due to the extreme urgency of the construction program, it was impossible to conduct exhaustive investigations of each man before he was hired. It had to be done afterwards and usually was not completed until he had been on the job many weeks. Leach observed:

Reports of investigations showed that a far too great percentage of employees had criminal records ranging from numerous arrests for drunkenness to convictions for grand larceny and rape. Those in the latter categories were fired as soon as discovered, which added to the already high labor turnover.

Judge Ardis Walker, who faced between 30 and 40 criminal cases each Monday morning, estimated that 60% of the people had a criminal record and stated, "Many of them were sent there as a condition of probation to help build the base."¹⁶

Complaints that contractors were not providing adequate housing and messing facilities were among the forefront of problems. The following is Leach's account of the legendary NOTS "Bacon and Egg Riot."

Trouble finally developed on the morning of May 17, 1944, when the men in the second seating at the mess hall (plumbers and electricians) refused to eat the meal that was served them. The commissary steward, in an effort to placate the men, asked them what they wanted to eat. They demanded bacon and eggs which was then served. As soon as the men had finished and gone to work, the word quickly spread among the construction crews that a favored few had been served bacon and eggs for breakfast. As a consequence, men all over the Station pulled off their work and by 9:30 A.M. approximately 1,000 men were milling around the mess hall demanding bacon and eggs.

Captain Sandquist and Mr. Case made personal appeals to the men to remain orderly and go back to work, following which an open air discussion was held regarding the problems of the men. Both Captain Sandquist and Mr. Case assured the strikers that strenuous efforts were being made to improve mess hall conditions. An aftermath of the strike was that the mess hall served bacon and eggs until nearly noon when the men returned to work.¹⁷

SUPPLIES AND SABOTAGE

In addition to labor priority problems, there were difficulties in obtaining construction supplies and equipment. Many were the irritating delays in obtaining building materials, particularly those for electrical, heating, and refrigeration systems. Often the completion of a badly needed facility was held up, and an otherwise unnecessary

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temporary facility had to be constructed on a stopgap basis. Original designs were based on conservation of critical materials and not on economy; and when construction started, the materials used were often those within reach at the time regardless of design or cost.

The supply problem was greatly complicated by the magnitude of the job. Huge quantities of materials had to be stacked on the open desert at widely separated sites. A unique feature of the early NOTS terrain was that, with a little zigging and zagging between creosote bushes, a truck could go just about anywhere without the need for a road. Thus, an unscrupulous raiding party could approach a stack of supplies from any point of the compass. An officer of Burroughs' staff expressed the opinion that several houses in the adjoining town of Ridgecrest were built from scratch with Navy materials and supplies.¹⁸ In time, the pilfering became so brazen that a thorough investigation was made of the situation and a more effective system of vigilance was sought.

A few cases of sabotage were experienced during the NOTS construction era, but usually they were traced to disgruntled workers whose number was legion in the Indian Wells Valley of the Mojave Desert in 1944. In addition to the cause—the unduly low morale—there was the ever-present opportunity to commit sabotage. In the opinion of Lieutenant Norman F. Main, the Station Security Officer, “any serious, well-planned attempt to sabotage construction would have been comparatively easy.”¹⁹ Happily for NOTS, such was not the case!

Through it all—sandstorms, isolation, primitive accommodations, rough-and-tumble social climate, labor problems, supply shortages, thievery, bacon and egg riot, and pinpricks of sabotage—the work moved on. And to the seemingly impossible building task originally outlined, there was added the requirement for constructing a large plant for the pilot production of rocket propellants.

CHINA LAKE PILOT PLANT

As previously noted, the key that unlocked the door to the nation's massive rocket program during World War II was undoubtedly CalTech's success in solid-propellant rocket technology.

In 1941 the Institute had leased a five-acre tract in the San Gabriel foothills northeast of Pasadena to locate a safe experimental ballistite production and testing facility, and thus remove explosives

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from the campus. But as the national need for rocket propellant expanded, "Eaton Canyon," as it was known, evolved into a major production and test facility; nearly 5,000,000 pounds of ballistite were eventually extruded there.

CalTech's assumed role of volume ballistite producer was not sought. On the contrary, it was always intended that once the designs and very special production techniques were worked out, they would be passed on to the Navy for use by large-scale production contractors. At that time CalTech would phase out of the production business and focus its scientific expertise on improved propellants and rocket designs. But demands for ballistite were overwhelming, and industry could not quickly tool up for volume production of a virtually experimental product. Hence, the experimenters became manufacturers out of necessity and as a wartime duty.²⁰

It was a situation that could not last. First, the anomaly of having outstanding scientists and engineers doubling as plant operations supervisors was costing much-needed experimental time and effort. Second, the resources of Eaton Canyon were finite. Its limits were reached in the fall of 1943 when a new 12-inch propellant press was needed to make larger rocket motors. Adding a large press would severely overtax the already marginal safety factors for large quantities of potentially hazardous materials.

CalTech wanted a facility that would help meet the Navy's needs for rush production of propellant grains as well as allow their own experimental propellant work. Moreover, they wanted such a facility to be at a safe distance, but not too far removed, from Pasadena.

The Navy was similarly concerned. It wanted a pilot plant where the propellant processing techniques could be refined and firmly established so that they could be readily adopted by the larger industrial plants. Such a pilot plant would firmly establish the Navy in the new rocket technology—especially if the facility was constructed as a permanent one.

In the fall of 1943 a team of CalTech scientists had begun looking at possible sites in Southern California. Two of these, near Hesperia and San Bernardino, seemed to be most promising for the Institute's purposes. But before these sites could be given intensive consideration, the prospects of NOTS being established near Inyokern appeared.

From the Navy's viewpoint, the NOTS site at Inyokern was a logical place to locate the new pilot plant. It was away from a densely populated area. Moreover, the NOTS leadership consisted of a

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Navy-CalTech team that was blessed by an unusually warm relationship—an important factor in view of the Bureau of Ordnance's wish that the plant be under CalTech's management control. But most important, the season was right for NOTS Inyokern. The appropriations tap had been turned on in Washington for the new Station, and a healthy stream of funding was beginning to flow; enough to include a propellant processing facility as part of NOTS.

CalTech was not as enthusiastic about locating the new plant at Inyokern, but accepted the decision of the Bureau of Ordnance.²¹ In late 1943 tentative agreements were reached among Dr. C. C. Lauritsen, the National Defense Research Committee, and the Bureau of Ordnance that "such an experimental unit would be built jointly by the Bureau of Ordnance and the [National Defense Research Committee], and that the California Institute of Technology, under Contract OEMsr-418, would furnish the detailed design and equipment, and that the Bureau of Ordnance would control general arrangements and safety matters."²² The ball was thrown to CalTech, which ran for the goal line. The man selected to spearhead the drive was Dr. Bruce Hornbrook Sage.

Sage was predisposed to hard driving: himself, the people who worked for him, and a battered Mercury sedan in which he achieved speeds up to 75 miles per hour over the tortuous mountain road and long stretches of desert between Pasadena and Inyokern; this while dictating into a wire recorder all the way at equal speed, often turning his head to address passengers in the rear seats.

The young, tall, balding Professor of Chemical Engineering perhaps had a need to drive hard. He was working at three jobs: professorial duties at CalTech; research work for the American Petroleum Institute; and together with Dr. William N. Lacey and Dr. D. S. Clark, he was co-head of Section V, Propellants and Interior Ballistics, Contract OEMsr-418—the largest section under this contract having some 264 Institute personnel.²³ But the greatest part of Sage's wartime effort was directed toward the new propellant plant at NOTS.

Both by agreement and the force of his personality, Sage was in complete charge. Design, construction, and subsequent operation were all within his responsibility.

Sage appears to have made the first of his furious drives to Inyokern on January 21, 1944. On that occasion he met with Sandquist and Burroughs to discuss tentative plans for the new pilot plant as conceived by Oliver G. Bowen, head of a consulting

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Courtesy Millikan Library, California Institute of Technology

Dr. Bruce H. Sage, pilot plant boss.

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engineering firm contracted by CalTech. Bowen had worked fast, since he had only been given the task on January 14, and within the week he had preliminary drawings showing floor plan and elevations, type of construction, and costs for the plant. The drawings included two large propellant press lines featuring the large 12-inch press needed for motors of the new 5-inch rocket, and an even larger 18-inch press capable of extruding grains 12 feet long and 9 inches in diameter. (The terms "12-inch" and "18-inch" (press) derive from the dimensions of the extrusion cylinder, not the diameter of the grain extruded.) The plan for the press lines called for three types of structures: 29 propellant processing buildings, 15 semipermanent and 18 temporary administrative buildings, and a large number of storage magazines.

The Bureau of Ordnance, after approving the plan "in principle," promptly (February 15) tapped their Naval Vessel Repair funds for another \$1,500,000. In turning the funds over to the Bureau of Yards and Docks, they stipulated that detailed plans be sent to them as soon as possible. The conflict between the desire to expedite and the need for reliable planning, particularly in respect to safety, can be observed by eavesdropping on a telephone conversation between Captain Byrnes and Captain Burroughs on February 11, 1944:²⁴

BURROUGHS: We had a conference out here the other day on the Powder Plant and as a result of that conference, it was finally agreed by everybody that if we must wait for detailed plans for the Powder Plant to be completed before getting bids and going through that bid routine and then before starting construction, it'd be impossible to get that first line into operation before June 15 and then Capt. Sanquist [sic] would like very much to go ahead with that Powder Plant on the—as the detailed plans are submitted. He can actually start, if he had authority, he could start construction here very soon. The plans are being turned out by CalTech and the first detailed plans will be in his hands as of Monday. The June 15 date seems to be the best that anybody can promise unless that cost-plus-fixed-fee arrangement is worked out.

BYRNES: Well, now, we want you to have the copies of those plans sent also to the Bureau by airmail because it involves the safety engineer's review of them.

BURROUGHS: Well, I was just going to ask you that question, sir. I wondered if the Bureau can give us dispatch approval of the general plan of the Powder Plant as laid out by Bowen in that plan...

BYRNES: Yes.

BURROUGHS: Give us dispatch approval of that general plan as regards safety distances between the buildings.

BYRNES: Yes, well, the safety engineer will also want to look at the buildings too. The details on how the buildings are to be constructed because there are certain features that he knows of construction such as making it possible for the wall to blow out without the roof falling down. We'll have to see the detailed plans too. That's why I say you'll have to send them in by airmail.

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BURROUGHS: In other words, the detailed plans for each building before it's constructed?

BYRNES: Well, he, if he gets one building, he can probably review it very quickly and send the comments out by teletype which will guide you in the others.

BURROUGHS: I see, yes, sir. I think it will be some time before the detailed plans for the building are completed, Captain.

BYRNES: Well, then . . .

BURROUGHS: If they have some approval, they could go ahead and start some initial work in laying out sewage and a lot of the roads and things of that nature, starting now.

BYRNES: Oh, well, we can give you that. We'll go over the plans and give you that. It has already been more or less approved by the Bureau and sent over to the Bureau of Yards and Docks.

BURROUGHS: Yes, sir.

BYRNES: So we can give you those details but for the individual buildings, which the safety engineer will want to look into because his experience is dictated by certain types and general forms of construction which should be complied with.

In the meantime, \$625,000 had been made available by the Office of Scientific Research and Development for the equipment for the new China Lake Pilot Plant—which by this time was starting to be known by the initials “CLPP,” familiarly referred to as “Clip.”

With the casualness of a man of professional confidence and the enthusiasm of one who loved the desert, Sage spent the better part of several days bouncing over the desert in a Navy jeep in search of a location for what he then called a “small pilot plant.”²⁵ He chose an area just east of the China Lake village; a choice prompted by the proximity of already planned housing for the workers who would operate the “small pilot plant.” Then, in the typical wartime aggressive spirit of striking while the iron is hot, a spirit that was essentially germane to the dynamic Sage, he gave the go-ahead signal to Captain Sandquist, who passed it in turn to his contractors, Holmes and Narver, architects and engineers; and Haddock Engineers, Ltd., construction firm. Sage also hired Joe Waller, described as “a tough breed of civil engineer,” to be the resident engineer for the pilot plant project.

On March 1 the bulldozers started to roll. The site was cleared, and new roads graded. Within three weeks the loading building for the 12-inch press line was 75% complete. Footings were poured for the press barricade.²⁶ But even as the signs of progress increased, there was a growing cloud of doubt.

On March 8, barely a week after work started, Byrnes and his assistant, Lieutenant Commander Dexter Bullard, came west to study the detailed drawings of CLPP.

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A meeting, which took place in Bowen's office in Los Angeles, was attended by Byrnes, Dexter Bullard, Burroughs, Sandquist, Lauritsen, Sage, Palmer Sabin (CalTech's own staff architect), and R. C. Stone (CalTech Plant Superintendent).

The reason for the meeting was clear. Byrnes had not received the detailed drawings and was apprehensive.²⁷ The drawings were, in fact, only about 50% complete on March 8 when Byrnes and Bullard arrived. However, they were complete enough for the Bureau of Ordnance men to make a judgment that what was being built east of China Lake village was unacceptable!

Principally, the Bureau of Ordnance felt that CalTech had misinterpreted the "New Jersey Tables of Quantity and Distance" (an ordnance plant designer's bible), which clearly prescribed layout as determined by the volume of propellant versus the distance between the various facilities—not only those of the plant itself but also adjoining facilities. At NOTS, these happened to be the officers' housing.

The whole crux of the matter centered on the question of whether ballistite should be classified as "high explosive" or "smokeless powder." Mr. F. F. Dick, Bureau of Ordnance's "Safety Czar," resolutely settled the question. According to Dick (known to his associates as "Doc"), ballistite was to be treated as an explosive and handled according to his strict safety directives that were wholeheartedly endorsed by the highest echelon of the Bureau of Ordnance and the Navy.

Architect Bowen had made his layout on the presumption that the rules for smokeless powder would prevail. Now, under the new ruling, the safety distance was not sufficient, not even for a small pilot plant as envisioned by Sage.

To the dismay of the CalTech scientists, the Navy asked not only for a change of location but also for changes in size of the plant and the type of structures. There were more than safety considerations behind these changes. Byrnes recognized the lead that the Navy, through CalTech, had taken in the development of solid-propellant technology in this country. He was concerned that the Navy be able to preserve this leadership after the war. It is reasonable to surmise a conclusion on his part that such leadership could be best ensured by having a first-class propellant pilot plant as part of NOTS.

What Byrnes wanted was a plant twice the size originally proposed, nearly 100 buildings. The location would have to be changed for reasons of safety and so there would be room for future

expansion. Construction would be for a permanent Class A plant rather than the temporary one planned by CalTech. This is essentially what Byrnes got as soon as he was able to report back to Hussey for concurrence. For Bowen it was "back to the drawing board." For Sage it was a bitter lesson in the importance of communication.

The new plant site, some 4 miles removed from the original site, rested on the rocky slopes of the Argus Mountain foothills. Years later, A. L. Pittinger, former Pilot Plant Officer for the Navy, recalled the selection of this new site:²⁸

The new plant site was actually selected by Sage, with the concurrence of the C.O. and OinCC and Captain Byrnes. Sage and I took several jeep trips to explore the area south of the mountain, which at that time was not officially within the Station boundary. In a meeting with Joe Waller and myself, Sage asked if we could run a fast survey of the approx. 3,000 acres of land. Joe was reluctant, but I suggested that we run it by jeep, using two jeeps, each with a rodman and driver, using the rear step of the jeep as the rod position. We had an expert surveyor, Larry Caulkins and a girl named Polly (later Polly Connable) who was the only female CIT employee on the Station at that time. I said I would get the two jeeps and a couple of Navy guys to help.

Sage liked the idea and asked us to start sending down topographical maps just as soon as possible. Well, we got going on a Friday and worked right through for ten days. We shot 5-foot contours over the entire 3000 acres, starting out right after breakfast and working until dark. Polly was the draftsman, and she would take our notebooks at the end of the day and help reduce the data so that she could plot the maps. We all pitched in, and for a bunch of amateurs (except Larry) a remarkable job was done. Bowen griped about not getting the whole set at once, but actually we kept him supplied with all the topo he could use for the preliminary plant layout.

Work was started in May 1944 with a small crew of workmen, just as Station construction was moving into full stride. Labor was scarce and so were building materials and construction equipment.

The complicated structures implied more than just permanent (Class A) concrete buildings. In line with the Bureau of Ordnance's rigid safety requirements, whole systems of intricate deluge sprinklers had to be installed. The minimum 100-pound-per-square-inch water pressure, in turn, necessitated increased thickness in pipe walls; the addition of pressure-reducing valves; and all valves, fittings, and fire hydrants to be of extra-strength material. Moreover, all electrical fixtures had to pass rigid explosion-proof standards.

Under the new plan the transfer docks of the 18-inch press line were connected to their respective buildings by a covered walkway. This required that the dock, building, and walkway be on a common floor level—some were maintained for a distance of almost 500 feet. Achieving this on rocky, sloping terrain was a monumental feat of excavation and grading.

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There were other problems. Each building in the desert environment had to be designed with its own individual air-conditioning and heating unit. Even sewers were a problem because the prevailing rock and general imperviousness of the soil made it necessary to develop a collection system and treatment plant for the whole area rather than use septic tanks at individual buildings.

But the largest problem of them all was the fantastic rise in costs of the new pilot plant. From January 1944 to the end of March the original estimate of \$1,081,406 had nearly doubled. Four months later, in July, it had doubled again, and the rise continued.

Sage termed the trend, "disquieting" and asked for a reevaluation of the policy, objectives, and designs of the plant. He foresaw the plant cost at \$5,000,000, not counting design costs, special equipment, housing, or other general support facilities. He compared this \$5,000,000 facility with its expected capacity of 15,000 pounds of propellant per day with the \$1,500,000 Eaton Canyon facility processing 8,000 pounds per day.²⁹

Despite a host of TWX's, speed letters, memorandums, and phone calls on the subject of reevaluation, the work on the larger and improved pilot plant went on. The Bureau of Ordnance wanted it, and the time for discussion was past. The Bureau's position was that rockets were important not only for the present war but also would become increasingly important in postwar defense; propellants were the key to rocketry; and an in-house propellant pilot plant was essential to propellant experimentation, development, and production. What was past was past, and the Bureau of Ordnance shared the responsibility for what it considered a false start.

Even after thirty years, the desolate foundations of the abandoned first pilot plant site can still be discovered to the east of what is now a golf course: a reminder of the fast pace of wartime development—both in mistakes made and in the rapidity with which plans changed.

The remarkable fact is that the false start had little effect on the tight schedule. In the rough log of the Petty Officer of the Watch for November 16, 1944, a triumphant little entry stands out among the more mundane reports of personnel returning from leave and the dispatch of the Shore Patrol "to patrol Ridgecrest and immediate vicinity." The entry in question reads:

The first grain of Ballistite Propellant was extruded from the 12-inch Press at the China Lake Pilot Plant at 1731, 16 November 1944.

A. L. Pittinger, LT (jg) USNR
Pilot Plant Officer³⁰

This historic occasion had its lighter side, as recalled by Norman Rumpp: "...all the wires hadn't been hooked up yet [and] they had an Admiral coming. Bruce [Sage] said, 'Have it working when the Admiral comes.' So they bored a little peephole in the concrete...they had a button for the Admiral." As the Admiral pushed the button, someone signaled Rumpp through the peephole and he touched two wires together, putting the press line in operation.³¹

Finally in operation, the China Lake Pilot Plant was largely a self-sufficient entity. It had its own administration, construction, maintenance, transportation, food services, fire-fighting and first-aid facilities, supply, and safety sections, and the experts to staff them. An efficient security force and a steel fence made it impossible for the casual visitor to amble around the plant unescorted; and this even applied to the NOTS people who lived down the hill.

This was the way Sage felt it ought to be. Having ascertained the rigid safety code for ordnance plants as required by the Bureau of Ordnance, the pilot plant boss felt that to achieve maximum safety, everything should be tightly controlled. And Sage achieved his goal. The China Lake Pilot Plant was a model ordnance plant.

If Sage's methods were sometimes regarded as totalitarian, that did not diminish the high regard he had from his subordinates. He was warmly referred to as "the Great White Father." As Rumpp put it, "He was a great guy—he pushed you but he never beat you!"

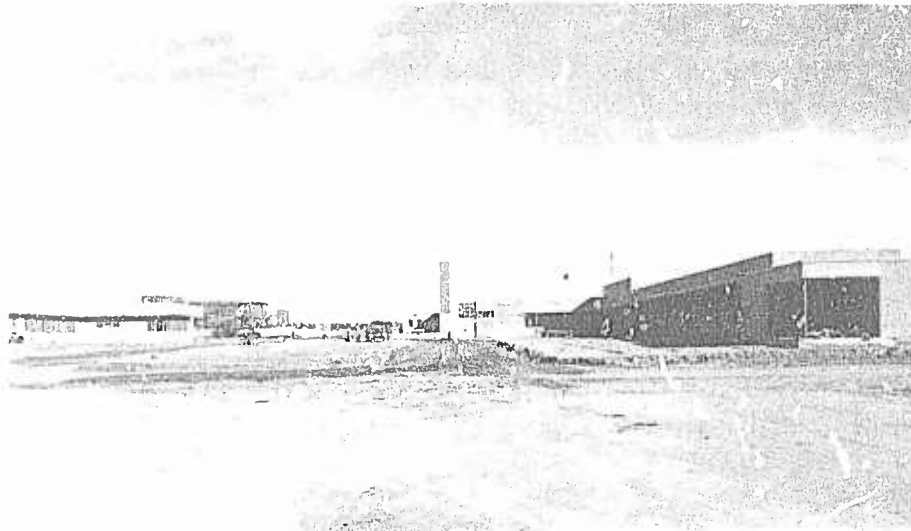
Even though the production of ballistite had started, the pilot plant was still a long way from completion. Only the 12-inch press line was operating, barely. To complete the 18-inch facility and get it into operation still posed a wide variety of problems that would need Sage's particular drive and talent for their solution. The output of the larger press was urgently needed for the huge, new Tiny Tim aircraft rocket having a diameter of nearly a foot, and requiring the production of grain in unprecedented dimensions.

But, for the most part, the major problems of the pilot plant were essentially over. If the rate of progress can be measured by the diminishing size of problems, the pilot plant work was advancing in great strides. As the problems of construction and production engineering were solved, the pilot plant boss found his attention turned more and more to all the detailed procedures that assume unusual importance in a plant where one spark at the wrong point in the processing could spell disaster. This made it necessary to have such procedures as requiring all employees to turn in matches and

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cigarette lighters to the security guard upon entry into the plant. These procedures are still required today. However, in 1944, all employees were subject to spot "shakedowns." If as much as a common kitchen match was found, the transgressor (male or female) was subject to instant dismissal, or at least suspension without pay for a prescribed period. The search procedure was recalled recently as having a lighter side. A former supervisor wrote, "We put out tables for the ladies and asked them to empty the contents of their purses. Usually the first time one package of paper matches might show up in a lady's purse. However, we found out there were many other things in the ladies' purses, somewhat and sometimes to the embarrassment of the ladies. After the first time the contents of the purses carried into the plant went down very markedly and there were only a few items which would need to be poured out of a purse in order to make sure that there were no matches aboard."³²

The various advocates of a pilot plant at Inyokern had initially held differing ideas as to its purpose. Nevertheless, as an accomplishment, the pilot plant would eventually prove to be all things to all men. For CalTech it was a fine, new propellant research and development facility, for the Bureau of Ordnance a fully integrated rocket-motor-loading plant that eventually produced many hundreds of thousands of complete weapons ready for shipment to the combat theaters.



China Lake Pilot Plant, January 30, 1945.

The Bureau of Ordnance also realized its principal goal of a pilot plant, functioning in accordance with tried and proven production techniques and safety practices, that could serve as a model by which to set up large-scale production facilities in various parts of the country. It could also "take up the slack" before the high-volume output of big industry could begin.

DEPARTURE

On November 30, 1944, suddenly and without warning, NOTS lost its master builder. At the peak of construction, less than a year after his arrival, Captain Sandquist received orders detaching him from duty at NOTS (as of December 1) and instructing him to report to Adak, Alaska.

If Sandquist was surprised, Burroughs was shocked! The Station Commander knew Sandquist to be the one man who had the complete construction picture in mind, the master in overcoming difficulties. A case might have been made for rescinding the orders. But it appears that it was Sandquist himself who insisted that Burroughs let the change of duty orders stand. He assured Burroughs that his leaving would not delay or hamper progress or seriously affect the ground rules and principles that had been laid down.³³ On the other hand, it is probably safe to conjecture that if a strong case had been made for his staying, a controversy might have been stirred up that would have adversely affected the project; for there were differing interpretations of Sandquist's role at NOTS.

The interpretation here is one gleaned a quarter century later from the local record of accomplishment, and through the evaluative statements of those in a leadership position at the Station itself—where the work was done and the obstacles he overcame were most apparent. In essence this interpretation reveals that Sandquist's year at NOTS was the "miracle year" of construction accomplishment, and no man played a more important role in that miracle than Sandquist himself. For despite the acute labor problems, the uncertainties of plans, and the constantly changing requirements, a substantive part of what would be NOTS for decades to come was well along toward completion by the time Sandquist received his new orders.

An unanswered question remains to tantalize the historian: Why the sudden orders and the immediate detachment from NOTS? Some

of Sandquist's associates later speculated that it was the result of an investigation of alleged delinquencies in safeguarding against the misappropriation of Navy construction materials; a clear case of imposing the doctrine of "the top guy gets the blame no matter what."³⁴

There is also room for speculation that in his practical approach to construction problems, Sandquist had cut some of the regulations too close, too often. For example, he had authorized an unusual plan for getting an extra bedroom for Senior Officers' Quarters. At the time, there was separate money authorized for the building of guest quarters; Sandquist suggested, and Burroughs and associates agreed, that instead of making one building for guest quarters, they add a bedroom and bath to each of the Senior Officers' Quarters. When distinguished visitors came to the Station they were indeed invited to stay in the "guest quarters," albeit located under different roofs.³⁵

Early in the game, Sandquist had embraced the Burroughs philosophy of "why do it twice," and as a consequence escalated the initial costs of the Station by leaning as far as possible toward long-lasting construction.³⁶ The fact that these structures would require relatively low upkeep costs for at least the next twenty-five years was possibly less important to some reviewers of Sandquist's performance than the immediate costs. From John Richmond we have a retrospective viewpoint some twenty-five years later:

Well, I think that Sandquist was a very excellent man. . . . He was not ever hidebound. He would listen to reason. . . . Where he got in trouble, I think, was [that] he had somewhat of an artistic temperament. . . . We went to work and got a lot of that decorative stone that he put in the theater and the facade of the stores and the library. Somehow or other I think the Navy Department thought he was sort of "gilding the lily" out there, and they weren't interested in making the place look pretty; they wanted a place that people could live and operate and things like that. So all of a sudden—one day in December—they yanked him out of there and sent him to Adak in Alaska. I felt sorry for him because he put in some touches, but we didn't tell him to take them out or anything like that. We thought it would be nice to have things like that too.³⁷

A possible clue as to official opprobrium, if any, is discernible in a Bureau of Yards and Docks "Memorandum for the Secretary's Committee on Public Works Projects."

The development of the station has been seriously delayed and performance of its function handicapped by the lack of business-like procedure in obtaining necessary new construction.

The most pointed criticism was leveled at "the lack of plans and change in design."³⁸

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When Captain O. A. Sandquist, USN (Ret.), was interviewed for this published history, the interviewer was not then aware of any mysterious circumstances surrounding Sandquist's departure; therefore, this subject was not brought up. However, the following informal comment subsequently added by Sandquist upon reviewing the interview transcript seems to apply to the situation.

Of course the problems piled on. The original idea . . . on which the basic estimate was based was on the temporary type of construction—so much used at the beginning of World War II. A great deal of that had to be done—but as the effective weapon results came in so good, it behooved us to figure much of the work more substantial and permanent—and more so as the war went along—BuOrd saw that as well as BuDocks—and of course costs piled up, the CO and Officer-in-Charge of Construction had to work that way—"to win the war"—even though it might give us severe criticism and censure but commendations are not won that way.³⁹

Sandquist left without commendations and under a cloud of implied criticism from distant quarters, but he took with him pride in having successfully directed the construction of the Station through its most difficult period. He carried with him also the high esteem of his own office staff, the Station Commander and Executive Officer, the contractor personnel, CalTech employees, and a host of people, uniformed and civilian, who worked and lived in the Navy city he had striven to build.

In January 1944, the Sandquists had driven into what seemed a land akin to "Hades with poison water." On their arrival at the NOTS Inyokern headquarters, the Station consisted of an airstrip, a few Quonset huts, and some barely scratched out rocket ranges. A year later, when Sandquist departed for Alaska, he left a large Navy station with comprehensive facilities for conducting critical wartime test and training programs; also, some 10,000 people, many working on wartime projects and many more building for a permanent ordnance center.

If Sandquist left NOTS by air, as it is assumed he did, he would have had the advantage of a unique overview of his eleven-month accomplishment.

Immediately after takeoff he would be aware of the largest community ever to be built, owned, and managed by the Navy taking definite form below him: over 600 homes and apartments well on their way to completion. He would recognize as completed the Officers' Mess and Recreation Building, Bachelor Officers' Quarters, Enlisted Men's Mess (the present Center Restaurant building), dormitories, dispensary and morgue buildings, a Waves' dormitory, a

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fire house, the Marine Barracks, and a unique brig designed to accommodate, if need be, both military and civilians. Incidentally, the records show that only a few "guests" were housed in the civilian side of the brig; principally, unruly laborers on a Friday night. The joint brig, however, perhaps reaffirmed the NOTS philosophy of military-civilian "togetherness."

Most impressive of all were the new community structures he would see rising up within the towering scaffolds, principally the large gymnasium and theater. He probably chuckled as he looked at the excavation for the 5,250-square-foot swimming pool that was justified in official planning documents as "water storage for fire protection."⁴⁰ If he happened to pick out the Navy Exchange and Library structures, perhaps he took delight in knowing that despite an overall simplicity of design, they had a little Sandquist touch of decorative design in the form of a rock facing.

From the same imaginary vantage point, the bright new, two-story Administration Building of permanent concrete construction



A community takes shape! Family housing with gymnasium (left) and Station theater (right) in foreground.

would be in interesting contrast to the rambling, wooden building that had served as the temporary headquarters of NOTS; and adjoining the temporary headquarters the Quonset hut that had been the office-with-sleeping-quarters originally occupied by Burroughs. In this same temporary headquarters area were about a hundred buildings of which his own former Officer-in-Charge-of-Construction Building was the largest. It might have been difficult even for the construction magician himself to recall that less than a year ago there had been just a patch of desert wilderness where he now looked upon a bustling community area.

As impressive and as critical as these community and administrative facilities were, Sandquist knew that it was the technical facilities that would be the making of the new center. That is why he would have been intrigued by a 10-acre maze of concrete forms opposite the new Administration Building; forms from which thousands of steel rods bristled like a bizarre new desert cactus. This was the beginning of what would later become Michelson Laboratory, the Station's main laboratory for ordnance research.

In the shadow of a small butte to the east of China Lake, Sandquist might have glimpsed the rocket-propellant pressing and other technical facilities of the China Lake Pilot Plant. Construction work was still in progress, but the 12-inch press line and its associated building were complete.

To the north of the community, the desert landscape had acquired a new man-made scar in the form of two 10,000-foot-long intersecting runways. Nearby, busy construction was in progress on a great hangar and a number of permanent buildings. This was the Experimental Air Center (Area "E") that would be activated within six months and later designated Armitage Field; a major construction project in itself.

But to a man of Sandquist's sensitivity, the view of Harvey Field below would have held special meaning. Behind the busy naval air facility—living quarters, shops, offices, and storage magazines—he might well have visualized the ghost of a solitary, rural county airstrip: the place where it had all begun!

Today, just as it was in December of 1944, when one leaves or approaches China Lake by air, the flight path comes close to an isolated grove of trees about 5 miles to the west of the China Lake Naval Air Facility. This patch of green in the desert was once a private holding farm—the old Stayer Ranch—absorbed by the Navy. On the property, Sandquist had arranged for a concrete slab to be

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constructed, as well as a few picnic facilities beneath the trees. It was originally intended to serve as a modest recreational site for contractor personnel. Upon seeing these improvements, Richmond had said in jest: "Well, it looks like you are building Sandquist Spa out there." The name stuck, and today the area is known as Sandquist Spa; a small green spot for relaxation in a vast expanse of desert—an appropriate but gentle reminder to all those who follow that someone named Sandquist had passed this way and left his mark upon the Valley.

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NA National Archives, Washington, D.C.
CARD Collection of Archival and Reference Documents at the Naval Weapons Center
FRCM Naval Weapons Center records stored at Federal Records Center, Mechanicsburg, Pennsylvania

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5

Ebb Tide of War

Wartime activity at NOTS peaked during the closing months of 1944. Thus, a turning point had been reached for Station construction—ranges, administrative and test facilities, Navy housing—and also for rocket development programs such as Holy Moses and Tiny Tim.

At this midpoint in the wartime operation of NOTS, another kind of activity was emerging: the planning and preparation by the Navy and CalTech to accommodate the irrevocable phaseout of the Office of Scientific Research and Development. This effort was to intensify during the first months of 1945 and involved decisions and actions that would profoundly affect the future destiny of NOTS.

CONSULTANT EXTRAORDINARY

A minor change in January 1945 in a Bureau of Ordnance contract had a major impact on the future leadership of NOTS. The change was in a contract with Lukas-Harold—a subsidiary of the Norden Company that provided management for the Bureau of Ordnance's Naval Ordnance Plant, Indianapolis, and which took its name from the middle names of Carl Lukas Norden and Theodore Harold Barth, the company's founders. In part the requested change read:

It is the purpose of these amendments to provide that the Contractor shall furnish and be reimbursed for under the subject contract the services of Dr. L. T. E. Thompson in supervising the selection of civilian personnel

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[author's italics] required to staff the Research and Development organization at the Naval Ordnance Test Station, Inyokern, California, when and as such services are approved by the Chief of the Bureau of Ordnance or his authorized representative.¹

Although unremarkable in itself, the contract change implied a great deal for NOTS. First, it showed that the Bureau was steadfast in its hopes for a research and development capability at Inyokern; second, it was a positive step in joining the career of a remarkable ordnance scientist with the ultimate destiny of the desert Station.

In light of the highly significant implication of the Bureau of Ordnance's January 22 action, it is fitting that we take a closer look at the subject of the contract amendment request: Louis Ten Eyck Thompson "Dr. Tommy" to all his military and scientific associates.

As told in detail in Volume 1 of this series, Thompson began his career as a scientist for the Navy at the Naval Proving Ground at Dahlgren in 1923. Besides being one of the first ballisticians in the nation, Thompson possessed a remarkable and unique attribute: he understood the essence of successful military-civilian relationships as well as any man alive.



Dr. L. T. E. Thompson, first NOTS Technical Director.

As Chief Scientist at Dahlgren for nineteen years, Thompson had a unique opportunity to study the couplings of military and civilian thought patterns in the scientific arena of naval ordnance. His military counterpart and close associate at Dahlgren was Commander (later Rear Admiral) William S. "Deak" Parsons, and the two men, both in their acts and the philosophy they mutually developed, represented the highest plane of military-civilian teamwork. They had served together under both enlightened and arbitrary military leadership at Dahlgren and had learned lessons from both.

Thompson's experience had another significant dimension. As Chief Scientist he enjoyed a professional relationship with the young officers whose sojourn at Dahlgren was an important part of their postgraduate ordnance training: men like S. E. Burroughs, C. E. Haugen, K. M. McLaren, M. F. Schoeffel, F. I. Entwistle, W. A. Kitts, K. H. Noble, P. D. Stroop, W. G. Switzer, W. V. R. Vieweg, D. B. Young, G. F. Hussey, and J. B. Sykes, to name a few who were later associated with NOTS.

Especially important in the "Gun Club" training days were the associations the young scientist developed with Hussey, who as a lieutenant had been instrumental in the hiring of Thompson at Dahlgren. The exchange of "Dear Tommy" and "Dear George" letters some twenty years later testified to this friendship and was a significant factor in resolving key problems in the postwar transition of NOTS.

Beyond friendship, Hussey and Thompson shared a common philosophy regarding science within a military framework. The essence of this philosophy acknowledged that both the military officer and civilian scientist are working for a common goal: better weapons for the Navy. To this end the roles of each man have a cyclic interdependence. Dr. Thompson, the scientist, described this as "... interactions the feedback effects that come from close association [of] operations expertness with sophistication in the technology side."² Hussey, the sailor, expressed his viewpoint: "[The naval officer] will go back to the Fleet with a scientific approach to the solution of problems out there; he will also go out with an understanding of what is coming. He will be in a position to interpret to the people in the Fleet what is going on and why it is going on."³

This kind of relationship, based on mutual respect, was a prime objective of the Navy's ordnance postgraduate program. Its achievement was manifested in the success of many ordnance

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developments in World War II and personified in the lasting, warm associations made initially by Dr. Tommy and his young officer students. Significantly, these same young officers were "four-strippers" and leaders in ordnance at the end of World War II: some like Hussey and K. ts, had reached Flag rank.

Through his many years of association with the Bureau of Ordnance, Thompson was familiar with NOTS from its beginning. Long before there were any thoughts of a research and development center in the California desert, he and Deak Parsons had been dreaming of a place where military men and scientists could work together as a creative team on naval ordnance. He had watched his dream take form at Inyokern under "Ev" Burroughs, a man strongly influenced by both Thompson and Parsons.

In 1942 Thompson left Dahlgren and went to work with the Carl L. Norden Company in Indianapolis developers of the historic Norden bombsight. As Norden's new Director of Research, he was primarily responsible for the design and building of the Bureau of Ordnance's Naval Ordnance Plant, Indianapolis, which was under the management of the Norden Company to develop and produce parts needed for the bombsight program. This sight was developed under contract for the Bureau, with the Naval Proving Ground, Dahlgren, Virginia, doing much of the testing. Thompson already had demonstrated some expertise in laboratory planning, having been instrumental in the creation of the Armor and Projectile Laboratory at Dahlgren in 1940.

Thompson's role in establishing Navy laboratories at Dahlgren and Indianapolis added further to his stature as the scientist most knowledgeable in organizing Navy research and development. Recognition of this expertise led to Thompson's first visit to NOTS in February 1944 with an invitation to give suggestions on the ultimate form of operation for the Station.* This visit was followed in late April by a return visit to Indianapolis by James Duncan, who was seeking from Thompson, among others, advice regarding the planned research and development laboratory for NOTS. From these and other early contacts it became apparent that NOTS needed the advice and services of Thompson on a continuing basis.

* How little known NOTS was is indicated by the incidental fact that Thompson, in going from Muroc (now Edwards Air Force Base) to Inyokern, went a circuitous route with his volunteer driver that took them south some 100 miles to Los Angeles and after directions by telephone from Burroughs, retraced the trail north past Muroc and then on to Inyokern. Neither the driver, Art Breslow, a later employee of NOTS, nor his associates performing tests at the neighboring Muroc for the atom-bomb program had ever heard of the three-month-old Naval Ordnance Test Station.

Besides having a clear concept of what the Navy needed in a weapon research and development laboratory, Thompson knew where the opposition might come from. An example of his insight and form of strategy is seen in a letter to Captain Parsons in September 1944 regarding NOTS:

...I am very much afraid that those in the Bureau who favor a huge "test" station are going to have too much to say about it. I have mentioned to several people that I think the best way to strike a working compromise is to give the test people all the tests they want, with plenty of facilities, but no primary authority in running the place.⁴

Fortunately, Hussey, as Chief of the Bureau of Ordnance, was among those who shared Thompson's view on the future importance of NOTS as a research and development center. Like Burroughs, he wanted Thompson's services to be increased in scope and to be on a more formal basis. By the end of the year, some particularly knotty problems were being encountered at NOTS. The laboratory plans had reached firm definition, but now Burroughs and CalTech were looking for a workable organization plan. They were also facing the problem of staffing the laboratory.

At this point Hussey took action in his formal request to Lukas-Harold for Thompson's services. About the same time, Burroughs announced to his staff that "Dr. Thompson would spend about 50% of his time at Inyokern from now on."⁵

Although the contract amendment specified "the selection of civilian personnel" as Thompson's sole function, he correctly interpreted it as being "not only to recruit personnel for the staff, but also to assist in setting up and directing the operations of the Research, Development, and Test organization, subject to the approval of the Commanding Officer, NOTS, Inyokern..."⁶

The Bureau of Ordnance was most anxious to have a new director on board as soon as possible. The Office of Scientific Research and Development was anxious too. On April 23, 1945, Frederick Hovde, Chief, Division 3, National Defense Research Committee, wrote to OSRD Director Vannevar Bush, "Representatives of the Bureau of Ordnance expressed their firm desire to expedite all matters pertaining to the organization and staffing of NOTS Inyokern, and indicated that they would make an early effort to strengthen the administration of the NOTS experimental program through the *full time* [author's italics] assignment of Dr. Thompson to the Station as Director of Research."⁷

As will be shown later, Thompson made extensive, but unsuccessful, efforts to interest some of the leading OSRD scientists

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to take the position of Director of Research. Added to the problems of attracting a key person to a remote desert location was that of the salary limitations. It would be more than two years before Congress would pass Public Law 313 that would allow the payment of high-level scientific personnel at rates above the top civil service grade.⁸

As the efforts to find a director of the technical programs continued unsuccessfully, there was a growing conviction at NOTS that the man best suited for the job was Thompson himself. Burroughs led the continuing campaign to get him to accept the position. He did everything he could to keep Thompson's visits to NOTS frequent and lengthy. He kept him deeply involved in the management problems, and through these tactics he secured his agreement to fill the post temporarily.

Thompson became the Acting Director of Research while still a contractor to the Navy. As an example of the difficulties of the arrangement, his travel orders between Indianapolis and Inyokern had to be signed by both Burroughs and the Commanding Officer at the Naval Ordnance Plant. Whether a logical arrangement or not, the Station had a *de facto* head of the technical side of the organization as the end of the war approached.

CONSTRUCTION WINDS DOWN

The tone of the new management for the construction program was clearly sounded when Captain Sandquist's successor, Commander D. E. Rockwell, Civil Engineer Corps, was introduced to one of the contractor engineers, who—in customary fashion—told Rockwell he was pleased to see him. The commander's response was that the contractor would not be so pleased to see him after a couple of weeks had passed.⁹

According to a summary report on the principal Architect-Engineer contract for NOTS, Rockwell immediately began "a campaign of criticism of all plans as being too elaborate and taking too long to prepare." Moreover, according to the same report, specific criticisms were not forthcoming when requested.¹⁰

Any speculation as to what had caused the apparent—and abrupt—change of the Navy's attitude toward the contracts should take into account the vast differences between the frenzied

circumstances under which contracts were undertaken in the midwar era and the relatively unharried circumstances of early 1945.

It was a time for reassessment, from the highest level of government down to individual shore establishments. The success of the Allies in meeting the threat of the "Battle of the Bulge" made it clear to our military and scientific leadership that the war with Germany would soon be successfully concluded. It was time, therefore, to readjust weapon priorities. Production of weapons, including rockets, was at its peak. Stockpiles were mounting. As far as new weapons were concerned, it was concluded by the leaders of OSRD that any weapon development not close to completion should be terminated because it was unlikely that it could be completed and produced before the end of hostilities.

Significantly, the consideration given to weapon development status was not the same as it had been at the climax of World War I. Then there had been little or no regard at the higher levels of government as to what should be done with the weapon development resources spawned during the war. When the war ended, virtually all support for experimental work was abruptly severed. This abandonment, combined with low military budgets and the policy of isolation that followed, had been noted by many junior officers who subsequently became military leaders of World War II. As admirals and generals, these men held onto the conviction that it would be a certain invitation to future aggression if the weapon research and development capabilities were allowed to erode. With the end of World War II imminent, the question was not whether the nation should continue its research and development work to keep the armed forces equipped with advanced weapons, but what form this should take.

In Washington the question centered around who should have cognizance of future weapon research and development. Could there be a peacetime version of OSRD? Should there be a central laboratory for all the armed services? At NOTS the questions focused on the validity of the construction plan that had evolved to date. Should construction continue on the basis of the original plan to make NOTS a research, development, and test center? Should construction go forward on the main research and development laboratory?

These questions were likely to influence Rockwell or anyone directing his efforts. In the preceding construction eras of Fogg and Sandquist, the main thrust was to get the job done. The job inherited

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by Rockwell was to finish the construction work at NOTS and at the same time justify it beyond criticism, even if it meant the most scrupulous accounting of what had hitherto been considered normal expenditures.

Almost before the NOTS construction team had time to digest Rockwell's new management philosophies he was relieved, and his job of reshaping the construction effort passed to Captain (later Commodore) Lewis N. Moeller, Civil Engineer Corps, who arrived in February 1945 to take over as Officer in Charge of Construction. The NOTS newspaper, the *Rocketeer*, described him as an "experienced civil engineer, construction expert and man who gets things done . . . a tall man with a tall job."¹¹

And the job, as Moeller saw it, was to continue Rockwell's reshaping of the construction programs under which NOTS was being built. At the time, the Macco-McKittrick-Morrison contract listed close to 250 different projects of which about 72% were complete (or nearly so), and 28% were either not started or barely under way. In Moeller's opinion it was time to halt construction at NOTS and reassess the Station's plans and contracting methods. Accordingly, on April 4, 1945, the contractor combine received the word:

You are hereby notified that conditions have arisen which, in the opinion of the Contracting Officer, make it advisable, for the interest of the government, to wholly cease work under the subject contract, and any and all change orders issued thereunder. Therefore the subject contract, including such change orders, is to be deemed terminated and all work thereunder is to cease on Midnight May 31, 1945 without prejudice however, to any claims which the government may have against you, jointly or severally. Further, you are to stop all work on the Laboratory Building immediately and you are hereby directed to do no work whatsoever on any school building.¹²

Appendix D lists the projects on the contract and their degree of completion at the time of the May 31 contract termination. The contract was 93% complete when closed, and the total cost was \$54,952,221.¹³

But the end of the cost-plus-fixed-fee contracts and the erstwhile easy-going contract relationships of the midwar era did not mean the end of NOTS construction. When Moeller issued his stop order, the planning for an enlarged Station was aggressively going ahead. It was known that when the war ended, OSRD would cease to function, and the Navy would have to conduct its own research and development at NOTS and its other laboratories. Specifically, plans were being formulated for the transfer of CalTech activities and programs to NOTS. An expanded future role for the desert Station was a certainty.



Captain Lewis N. Moeller, Officer in Charge of Construction at NOTS in early 1945.

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Confirmation of this expanded role came on May 10, 1945—two days after Victory Day in Europe. Admiral Hussey wrote:

The construction, equipping and staffing of the Naval Ordnance Test Station, Inyokern, California, are currently being expedited as much as practicable with a view to the Station's assuming at the earliest practicable date all tasks of research, development, design, and testing of the Bureau's development program on rockets, related material, and such other similar activities...¹⁴

Through the efforts of the Bureau of Ordnance, arrangements were made with an alternate contractor—Haddock Engineers, Los Angeles (builders of the China Lake Pilot Plant)—to eventually complete most of the projects that Moeller had summarily halted as extensions of their current contract. Thus, by the end of hostilities with Japan, which concluded World War II, the NOTS facilities that had been started during the Sandquist regime were essentially complete.

But there was one major exception that represented the most critical facility of all: the research and development laboratory. The April 1945 order to stop work on the laboratory made it a near casualty of the war.

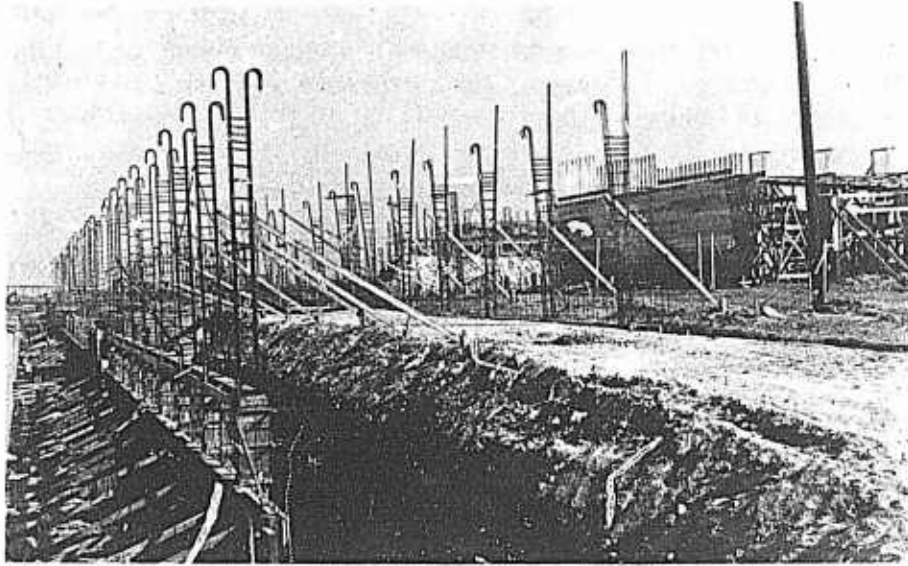
“BUILDING NUMBER FIVE”

It was not usually referred to as the “research and development laboratory.” The planners at both Inyokern and the Bureau of Ordnance called it simply, “the Lab,” a singular appellation that stemmed from the early decision not to build separate laboratories for each major area of research.

The workers of the firm of Macco-McKittrick-Morrison knew it as “Building #5.” This identification, as the fifth building project at China Lake, substantiates its earliest consideration and inclusion in the master plan for the Station. But beyond this, neither designation—“the Lab” or “Building #5”—reflected the importance of this particular facility to NOTS.

For until it was completed and in operation, Blandy's concept of an integrated research, development, and test center could not be fully realized. Therefore, it is appropriate to examine the reasons why Building No. 5 was not the fifth building to be completed at NOTS. Rather, why it would be one of the last to be completed in the main era of construction.

The predominant reason was clearly a construction delay that seemed implicit from the beginning. Between site selection and



Michelson Laboratory under construction.

clearing, which was sometime from early spring through August of 1944, no construction work had been accomplished. When considering the astonishing rate at which other major facilities were "topping out," the delay appears unusual. However, within the larger picture of total construction at Inyokern, the delay is easier to reconcile: it was a clear-cut case of construction priorities.

From the moment the Station was established, these priorities were clear. NOTS urgently needed facilities to support the wartime mission of rocket development and testing: air and ground range installations, roads, shops, warehouses, and temporary housing. There was to be no interference in meeting these wartime needs by the construction of the permanent facilities that did not also have clear application to the wartime programs. Many of the permanent facilities like the new airfield and the pilot plants clearly met immediate as well as long-term needs. The case was not so strong for the construction of permanent housing and the laboratory. As the laboratory was part of the long-range peacetime needs, there was no haste on the part of its planners to rush its completion. Instead, the time was used in an attempt to apply the most careful and detailed planning to what Burroughs had termed "the finest laboratory of its kind."

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During the last months of 1944 the foundations had been poured. In a telephone conversation with Captain Byrnes on October 25, Commander Richmond, the Executive Officer, said, "The laboratory of course probably won't be ready until next June or somewhere along there..."¹⁵ It would, in fact, be nearly three "Junes" before the laboratory would be ready.

With the new year, 1945, construction seems to have really gotten under way. Photographs taken between January 30 and February 14 show foundations and steel reinforcement rods reaching to the level of the second floor in the main building. It was at this stage of construction that major design problems came home to roost and make their impact on the project in terms of further delay.

These problems were not new, as the entire design phase of the NOTS laboratory appears to have been one of almost continual evaluation and reevaluation.

As each proposal was submitted by the Bureau of Yards and Docks, it was met by a counterproposal by the Bureau of Ordnance. A cycle of meetings took place in Washington, Pasadena, San Diego, and Inyokern. Memorandums filled the "In" trays; long-distance conference calls were frequent and lengthy. Representatives of the two Bureaus and NOTS accumulated vast amounts of travel time. Laboratory planning, including major reallocations of space, was constantly undergoing change during the final design stage. For example, doubts of CalTech advisers as to the need for further research in chemistry and metallurgy by the Station reportedly influenced a decision to put these functions together in one wing rather than in separate wings. This left one wing, which initially was assigned to ballistics.¹⁶

Of course these design refinements were vitally necessary. Although the Bureau of Ordnance had decided to go "first-cabin" on the quality of this permanent research facility, the specter of cost overruns was forever present. The costly hazards of faulty initial design were intensified by the ever-present need to design for flexibility so that the inevitable needs for change in the future research programs could be met. From James Duncan's account, the design problems are further revealed:

Since the original plan included the possibility of almost any kind of experiments being performed in any wing, it was necessary to provide all facilities such as hot and cold water, compressed air, gas, vacuum, direct and alternating current of various voltages.¹⁷

It became increasingly obvious that to provide *all* of these utilities to *each* laboratory room, while desirable, was quite out of

the question. Instead, an alternative plan was evolved whereby a 12-by 14-foot service tunnel would run under the central section of the building and under the full length of each wing; this tunnel would carry the necessary main utility pipelines (water, gas, vacuum, and electrical current) and enable appropriate taps to be made by any room via smaller connecting service trenches.

But while the designers were heavily engrossed with the problem of bringing water (among other utilities) into the laboratory rooms, no one apparently gave a thought to taking it out. Consequently, drain lines were missing. This anomaly was discovered quite late in the subsequent building program and required an extensive change order to correct.

Duncan put his finger on various design inadequacies and was able to have them corrected; one of these, for example, concerned electrical power for the cafeteria in the laboratory. Characteristically, he used direct, easily understood terms to point out this particular deficiency:

The 100 square foot kitchen in a modern private home will have three to four times as much power as is being asked for this laboratory. A Westinghouse Viceroy Model Electric Range is wired for 10 KW. The 0.6 KW [per BuDocks proposal] would not operate the smallest hot plate on this range except at half speed.¹⁸

Adequate power for the laboratory meant more than lighting and the operation of machinery and scientific apparatus; it directly concerned a most controversial problem of fundamental design—air conditioning. Before it was solved, this particular problem had generated pages of correspondence, required consultation with the nation's leading authorities on the subject, and made an air-conditioning expert out of the already versatile Captain Byrnes of the Bureau of Ordnance.

Apparently the most formidable characteristic of the Mojave Desert, the summer heat, was not precisely understood by the Bureau of Yards and Docks when it specified a primary system of evaporative cooling for the NOTS laboratory. They had considered that the humidity level in the desert was constantly low, the only condition for which evaporative cooling is effective. The people at NOTS, who had already experienced nearly a year of living in the desert, knew better. To qualify and quantify this experience, Duncan obtained temperature and humidity records from the Weather Bureau in Washington. The records revealed, in fact, that there were a great many days in the summer when evaporative cooling could not give the temperature and relative humidity conditions desirable for people and laboratory equipment.

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Further, the data showed that not enough consideration had been given to the heat generated by operating laboratory equipment. Duncan tersely pinpointed the problem.

Since the laws of thermodynamics have not been repealed it is obvious that all the energy that is used for experimental purposes is eventually converted to heat. This heat must be removed by the air-conditioning system.¹⁹

Duncan pressed for "a complete refrigerated air-conditioning system" that could be readily adapted to the existing ducts. His consultations with nationally known experts in the fields of industrial medicine and air conditioning provided opinions supporting a strong case for refrigerated air, not necessarily for the comfort of people, but clearly for the equipment in a research laboratory in the desert.

On February 3, 1945, a meeting was held in Washington with representatives of the Bureau of Yards and Docks and the Bureau of Ordnance. Duncan later recalled:²⁰

Although Captain Byrnes had never had any experience with this sort of thing, he took my notes home one weekend and learned enough about air conditioning so that he was able to prove to the BuY&D representatives that they could not give us the temperatures that they themselves had said they were going to provide in the laboratory with evaporative coolers... It was amazing to me how quickly Captain Byrnes got to the meat of the story.

He really made a study of this thing, and when the Y&D people came... they had to admit finally that they had not calculated the process....

...While we were arguing about this air conditioning, Lieutenant Phillips, who was a member of the Y&D group said to Captain Byrnes, "If you don't make Lieutenant Commander Duncan quit holding us up with these changes, we won't get this laboratory built before the war is over." And Captain Byrnes said, "Young man, we're not building this laboratory for *this* war; we are building it for [the next war]."

Duncan's recollections of the meeting include further evidence of how Byrnes did business and also indicate the unshakeable resolution of the Bureau of Ordnance to build a first-class laboratory:

...when we were talking about whether we'd get the air conditioning or not, one of the first things they [BuDocks] said was, "If we put in this air conditioning it's going to cost a million dollars," and Captain Byrnes said, "I didn't ask you how much it was going to cost; I told you we were going to have it."

That was the end of that problem! The day of reckoning on funds would come later. But that day was not far off for, as we have seen, in April 1945 Captain Moeller wrote the contractors, "You are to stop all work on the Laboratory Building immediately."²¹

For nine months, the foundations and beginnings of walls for four wings of the laboratory would stand neglected and untended, but certainly not forgotten.

CONTROVERSY AND REASSESSMENT

Almost from the beginning of the Bureau of Ordnance's plan to construct a large permanent research laboratory, there had been questions concerning the wisdom of choosing the Mojave Desert as its location. In April 1945 when all construction was summarily halted, the questions were asked again.

There was never any challenge to the Bureau of Ordnance's desire and need for a permanent, peacetime research laboratory, just as there had been none to the establishment of a large ordnance test station in the desert. The questions were asked about the necessity of having both the laboratory and the test station at the same site. Surely, it would be better to build the laboratory close to a metropolitan area—say Pasadena, California.

The proposed alternative location for the laboratory gives a clue as to the identity of at least some of its advocates: the NOTS contingent of CalTech scientific personnel, who regarded Pasadena as their permanent home. In the spring of 1945 these civilians were coming to grips with personal decisions imposed by the imminent phaseout of OSRD: namely, whether to transfer to civil service and continue working for the Navy, or to terminate their association with ordnance development. The building of the laboratory close to home must have been attractive to contemplate.

It seems that by far the strongest case for a Pasadena location rested in the essential remoteness of NOTS, which was seen to be a restricting factor in recruiting high-caliber scientists for a peacetime operation. This factor was further compounded by the inadequacy of Station housing and the lack of a settled, surrounding community. On the other hand, a Pasadena location offered easier access to established scientific libraries and other university facilities, as well as a large, scientific community, both industrial and educational.

In sum, the arguments for accepting losses on the poured foundations and preliminary steel work at Inyokern and making a fresh start in Pasadena held considerable logic. However, the proponents of the desert location also had a strong case.

These advocates of an *integrated* research, development, and test center—one that could handle all the elements of a weapons program from initial concept to verified hardware—envisioned a time when the housing problem would be solved. They foresaw a time, too, when the quality of life in the vicinity of NOTS would satisfy even the most discriminating civilian scientist and his family. They also felt

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that the remoteness and isolation of Inyokern had a positive quality in the preservation of security for sensitive weapon development programs.

The first round of arguments had begun in August 1944, even as the site selection and clearing process for the laboratory was being completed at NOTS. On the 30th of this month, E. C. Watson, administrator of the CalTech rocket program, drafted a proposal that was heartily endorsed by Burroughs, calling for a new weapons laboratory to be built in Pasadena. It was to be built and maintained by the Navy or a "more inclusive national organization."²² As proposed, the research staff of highly competent scientists would work under a civilian director who had a high degree of independence and continuity. The laboratory would take over the rocket and underwater ordnance facilities supporting the CalTech Contract OEMsr-418. This contract, under Lauritsen, was being considered separately from another CalTech rocket program, under Dr. Theodore von Karman, that formed the basis for building CalTech's Jet Propulsion Laboratory in Pasadena.

Under the August proposal, the Station in the desert would primarily be a test facility to support the research and development of the new Pasadena laboratory. Key arguments for a laboratory in Pasadena included the following: it was close to the torpedo and water entry facilities of Morris Dam; it was a metropolitan area where it would be easier to recruit and where there were many advantageous business and technical contacts; and it also offered the opportunity for rotating people so the Inyokern staff could have "an occasional tour of duty in town."²³

The Pasadena laboratory plan contrived by the officers and scientists out west was not met with equal enthusiasm in the eastern headquarters of OSRD. And without the support of OSRD leadership, there was little chance of selling the concept to the top echelon of the Navy. Frederick Hovde, who was one of Vannevar Bush's closest advisors in the management of the nation's scientists, set the tone of the response, "We do not need new facilities for our postwar program." He added:

At the moment, NOTS, Inyokern, seems to be the only Naval research center on the Pacific coast likely to be maintained as a peacetime Naval facility. If that is true, it will be the natural center for military research in that area. The New Weapons Laboratory you propose should be a branch of NOTS, Inyokern a branch station located in the metropolitan area to provide offices, etc., for the Inyokern staff, and the point of contact with all academic and industrial facilities of California.²⁴

In all, Hovde showed a warm concern for the future of NOTS for, among his closing thoughts to Watson, he included, "Whatever strength we can give to Inyokern now will enable the infant to withstand, I hope, the rigors of peacetime malnutrition."²⁵

When Hovde expressed these sentiments, construction of the Inyokern laboratory was already under way albeit only at a site clearing stage: a fact that was interpreted by many that the location controversy had been settled. Eight months later, in April 1945, the summary halting of construction triggered the controversy anew.

The laboratory location controversy had wide implications bearing on a problem that was already being faced regarding the future of NOTS and the rocket program. It was already clear that if the momentum and skills built up by CalTech in ordnance were not to be lost, serious consideration would have to be given immediately to what form the ordnance experimental work should take in peacetime. Questions were being asked about the accomplishments to date: Where do we stand? Where do we go from here? Answers were needed.

As part of the reassessment brought to a head by the termination of the contract, a second on-site survey of NOTS construction and facilities planning was made in June 1945.²⁶ This was the second such survey, the first having taken place in November 1944. The findings are contained in "Memorandum for the Secretary's Committee on Public Works Projects" dated June 27, 1945. A strong criticism of construction progress at NOTS is implied throughout the document. The team chose to stress the deficiencies rather than to recognize real accomplishments. Particularly lacking is any reference to the profound difficulties under which the Station had been built: the initial lack of any comprehensive plans, and the urgency of construction prompted by the nation's wartime needs in many cases before plans could be developed. Nor is any mention made of material shortages and the critical labor problems, the lack of a labor priority, the necessity of using the Station while it was in the process of actually being built, and a host of problems that stemmed from the remoteness and isolation of the site.

On the positive side, the survey conclusions strongly affirmed the importance of NOTS, and that the original planning of the station was considered good. It was further concluded that, although the Secretary of the Navy had approved overruns of expenditures upwards of \$5,000,000 after the November 1944 on-site survey, it would now be necessary to approve additional overruns to the extent of

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\$4,373,900. The investigators felt that the amount of construction during the intervening six months had not justified additional expenditures of this magnitude. They recommended that most of the additional money be acquired; however, it was on the condition that "some businesslike procedure for handling the future administration of Inyokern" be established.²⁷

Apart from the laboratory, the end of the war and Contract NOy-9088 did not spell the end of all construction at NOTS. But never again would there be progress on the same scale, nor approvals without detailed justifications and numerous reviews.

There was still so much to be done if the Station was to fulfill its destined role. In mid-1945 expanded technical facilities, bigger shops, and more completely instrumented ranges were already seen as requisites for the development of more sophisticated weapons.

One of these important necessities, the Experimental Air Center, had already been realized.

THE AIRFIELDS

In late May 1945, a little more than a year after it was officially formed, the Naval Air Facility transferred its pilots, planes, and equipment from Harvey Field to the newly constructed landing field near the ranges in the main Station area. This was the Experimental Air Center—Area "E" on the original plan for NOTS.

The transfer was regarded with mixed feelings. In the eighteen months of Navy occupancy and buildup, a small but well-defined footprint of tradition had been imprinted at the former Inyokern airfield. Even the humble Quonset huts that housed the enlisted men had been given distinguished names such as Lexington, Hornet, Enterprise, Essex, Saratoga, Intrepid, and Wasp. Moreover, even in 1945, it gave a man pride to say, "Yep, I was one of the first Harvey Field-ers in the winter of '43."

But there were just as many whose experiences rendered their association with the field less than pleasant, principally, those who had struggled firsthand to cope with the lack of necessary facilities to keep aircraft (Fleet training and rocket testing) flying. To these, even the name of the new facility, "Experimental Air Center," suggested a fuller share in the exciting weapon development program.

Aside from personal feelings, there is much to be said about Harvey Field and its historic relationship to NOTS as the Station's

genesis, and the Navy's means of establishing a foothold in the desert. The "old Inyokern airstrip" provided a first headquarters for the burgeoning Station staff of administrators, pilots and crews, ordnancemen, and a nucleus of personnel needed to operate a shore establishment. It had also housed the CalTech scientific and engineering staff. The swiftness that characterized its coming into being enabled NOTS to "open for business" immediately with vigorous Fleet training and rocket testing programs. Essentially, Harvey Field was the veritable platform from which the implementation of a permanent ordnance research, development, and test station was launched.

But it was never intended that Harvey Field should permanently carry the entire burden of air operations. From the outset, the Station planners had foreseen the need for a permanent, modern airfield close to China Lake that would be a base for the experimental air operations underlying the primary mission of NOTS. Construction had started almost simultaneously with the rest of the other permanent facilities: the headquarters, community, laboratory, and pilot plant. Now, more than a year later, the new airfield was ready for use.

To pilot and ground crew alike, there must have been delight in beholding the three smooth black runways, 2 miles long, with the ultimate in modern field lighting; the gleaming white control tower and the first of three enormous concrete hangars, large enough to house the largest airplane of the time. This was the B-29 bomber, built by Boeing and sometimes called the "Superfortress"; it could carry a bomb load of 10 tons.

A lot of care had been expended to build this field. Lieutenant Commander Pollock and his AODU-1 pilots had worked hard with the designers and contractors on some of the advanced features such as appropriate facilities for storing and loading fuel, adequate maintenance and administration facilities, and also safe ammunition loading areas. Curiously, for a climate that claimed little more than 3 inches of rainfall per year, there were difficulties concerning drainage: one problem, as Pollock recalled, was "to keep the lights from flooding out for night flying..."²⁸ The desert phenomenon of sudden flash floods, or "gulley washers," had to be provided for.

When it was done, the new field was indeed a noteworthy home for the NOTS air facility. There were shops, storehouses, and an armament assembly station; a gasoline storage of 200,000 gallons, and oil storage of 20,000 gallons. And it was all located less than 4 miles from the new permanent headquarters and village of China Lake.

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Aerial view of Armitage Field with F7F aircraft in foreground.

Before the runways were cleared for use, the field was named "Armitage Field," honoring the popular young aviator who had lost his life while testing a Tiny Tim rocket. The name was chosen by Lieutenant Commander Vossler and by the consensus of his pilots. Commander Hayward warmly received their suggestion and relayed it to Burroughs. The Commanding Officer had no hesitation in endorsing the name honoring Lieutenant Armitage.

Commencing in May 1945, NOTS boasted two airfields. While the future of Armitage Field was assured because it was the hub of experimental operations and the home of the Naval Air Facility, the same could not be said for Harvey Field.

From the time he arrived until he left, Burroughs fought to make Harvey Field part of the Navy's permanent inventory. The plan was to develop the field as a training air center supported primarily by the Bureau of Aeronautics, and then to build an experimental air center in the main Station area where it could support the weapon development work that would essentially be Bureau of Ordnance projects. This plan still seemed reasonable when the Experimental Air Center went into operation at Armitage Field. At that time Harvey

Field was still going, as one senior officer put it, "full blast."²⁹ Not only was there Fleet training in air-to-surface rocket launching tactics, but there were also other Bureau of Aeronautics operations, including those of a Drone Utility Unit for providing pilotless aircraft as aerial targets and a small guided missile unit serving as the nucleus of a broader guided missile development program on Project Lark.

Despite Burroughs' determination, the intricacies of diverse intergovernmental interests thwarted his desire to make Harvey Field a permanent part of the Navy.

The key problem was in obtaining ownership or a clear long-term lease on the 1,240 acres occupied by the airfield. The roots of the problem went beyond the agreements reached October 29, 1943, by the Interdepartmental Air Traffic Control Board, which had opened the way for the Navy to begin operations at the Inyokern strip and to develop the NOTS ranges. Following the understandings reached then, the lease the War Department held with Kern County was reassigned to the Navy. Unfortunately, the War Department lease granted use of the property to "only a date ending six months after the termination of the unlimited National Emergency."³⁰

In April 1944 Burroughs led a move to purchase the field for \$6,000, the amount Kern County had invested in it. The County at that time was agreeable; however, the Civil Aeronautics Authority, which had developed the airfield in 1933, protested strongly. According to the CAA, purchase of the field would violate a long-held understanding between the CAA and upper echelons of the Navy: that CAA-developed airfields would be acquired only by lease, and that such leases limited use to six months past the end of the war.³¹

The Navy had continued to press for purchase of the land but had been set back in September 1944 when the County reversed its position and opposed Navy acquisition. This change may have been influenced by considerations within the CAA that the airfield at Inyokern could become "an important link in airways to be established after the war."³² The NOTS reaction to this is indicated in the response of Vossler when he read of these speculations. He had jotted down an impulsive "Impossible!" in the margin of the letter. If anything, he had surmised, "the important link" would be nothing more than an "emergency airfield." In any event no important link developed in the next thirty years, and the County's change of position ended its main chance of obtaining a training air center within its borders.

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Subsequent efforts would be made by the Navy to obtain the field, but time was beginning to work against the probabilities of success. No major permanent facilities were being added because the lease did not adequately protect the Navy's interests, and this in turn lessened the chances.

In April 1945 Burroughs again raised the question of control of Harvey Field. This time his concern was aroused because of the Army's reawakened interest in its old claims. Burroughs wanted to avoid "the possibility of conflicting interests," understanding as he did the importance of air space control when two military air facilities are operated near each other.

It appeared to those concerned in the Bureau of Ordnance that permanent possession could not be obtained at that time, so a lease transfer was requested by the Navy. The transfer became effective on June 15, 1945. Under the terms of this lease, the Navy agreed to assume all obligations outstanding in connection with the land, including the obligation to restore it to its original condition at the end of the lease.³³

Significantly, the main operations at Harvey Field were under the cognizance of the Bureau of Aeronautics. As a consequence, the fate of the field depended not only on the initiative of Burroughs at NOTS and concurrence of the Bureau of Ordnance but also on the vigor with which the Bureau of Aeronautics would support the effort and the cooperation of the two Bureaus on the Inyokern operations. Burroughs, in trying to develop a one-happy-family approach to the problem, walked into a trap.

The beginning of the episode is revealed in a letter to Burroughs dated April 5, 1945, from the Chief of the Bureau of Aeronautics, Rear Admiral (later Admiral) DeWitt C. Ramsey:

Dear Burroughs:

The question continues to arise here about the possibility of Bureau of Aeronautics and Bureau of Ordnance conflicting interest in the general administration of Inyokern and its activities. You will recall that on the occasion of my last visit we discussed this matter briefly and you said that you would send me a personal memorandum on the subject. Will you be good enough to let me have this at your earliest convenience.

With best wishes,

Sincerely yours,
Ramsey³⁴

Burroughs returned a lengthy personal letter to Ramsey in which he advocated, among other things, that the Bureaus of Aeronautics and Ordnance make NOTS a joint venture (with Aeronautics providing

an appropriate share of the funds).³⁵ He sent a copy of the letter to his Chief, George Hussey. Years later, Burroughs described what happened:

Hussey got this letter and boy he blasted me; got on the phone right away. He said, "This is an ordnance station; you report to me"—and a few other words! Then he followed up with a letter [saying] "Don't get off the track; this is an ordnance station." I think what he meant to say is: "When you get in trouble out there and you're not getting satisfactory results from the Bureau of Aeronautics, come to me; I'll see the Chief of the Bureau of Aeronautics and we'll work out something," which was the correct way, the Navy way of doing things. I was off-line on this letter.³⁶

Although the Bureau of Ordnance retained control of NOTS and its ordnance programs with bulldog-like determination, the same cannot be said for the way in which the Bureau of Aeronautics asserted its interests at Inyokern. Not that the particular activities at Harvey Field warranted similar assertion. The Navy would face a massive demobilization of combat crews rather than an urgent need for Fleet training; the location of the Aeronautics guided missile program at Inyokern was always intended to be temporary, pending completion of new missile testing facilities at Point Mugu, California; and the Drone Utility Unit could just as readily conduct their operation from Armitage Field.

For the Bureau of Aeronautics, as well as the Bureau of Ordnance, a realization was beginning to dawn; namely, that the old original NOTS plan for large-scale training operation would radically change with the closing hostilities of World War II. The arguments on the importance of continuing, if not increasing, weapon research and development did not necessarily apply to the same extent to the training in the use of the new weapons.

Although it leads us beyond the period covered by this chapter, we should follow this Harvey Field story to its conclusion. The NOTS attitudes on the subject were still stormy to the end of the war. This is clear from notations on a route slip: "We should acquire this field.—Captain Entwistle agrees... —H [Hayward]"; "Recommend we stick to our guns—C. F. Vossler"; "Agree—Sykes." Prophetically the slip was dated August 10, 1945, the day the Japanese cabinet decided to make an offer to surrender. That decision would bring about a marked curtailment of training and the collapse of the main justification for a training air center at Inyokern.

Looking even further into the future, we find operations at Harvey Field diminishing rapidly after the war, and in April 1947 the field would be declared "excess to the needs of Naval aviation."³⁷ It had contributed mightily to the war effort in the three and a half

years since Commander Renard and Dr. Lauritsen had landed there while in search for a place to test rockets, and Lauritsen had enthusiastically proclaimed, "I want it; this is it!"³⁸

PLANNING FOR PEACETIME

The transition of NOTS from a wartime station serving the rocket programs of CalTech and the rocket training needs of the Fleet to that of a permanent center for weapon research and development did not occur within a narrow span of time that can be neatly pinpointed in a chronologically organized discussion. For this reason, a glimpse back to the beginnings of NOTS is necessary in order to see where the planning began for the passing of the torch.

That there was to be a major change in mission and structure of the Station at the end of the war was preordained by the quite different sets of wartime attitudes of naval officers and scientists toward peacetime weapon research. Many naval officers, particularly those who were members of the "Gun Club," strongly felt the need for the Navy to move into the postwar era with an effective research and development program. The CalTech scientists, although concerned with the future security of the nation, quite properly felt the time was coming for them to return to academia or other peacetime pursuits.

From the time a West Coast ordnance station was first proposed to Rear Admiral Blandy, he began shaping the initially limited proposals into far-reaching plans for a postwar center. The reason he felt this was so important is seen in his words of December 9, 1943:

Ordnance, more than other naval activities, needs this special attention to the research, because unlike ships, aircraft, communications, etc., it has no counterpart in civil life, and thus derives little from developments springing from the normal pursuits of the people in time of peace.³⁹

From Captain Parsons we have another example of the wartime thinking of naval officers in ordnance:

Research and development in military establishments is as necessary as industrial research. The reason is that industrial laboratories are necessarily focused in peacetime on the most urgent problems of industry—it is against human nature to expect industrial laboratories to concentrate first-class talent on the solution of a military development problem whose solution requires years of hard work and has no obvious industrial applications.⁴⁰

The above examples reflect the midst-of-war attitudes of many naval officers, particularly those in ordnance. These attitudes permeated the management philosophy of NOTS.

As early as June 1944 Burroughs was assuring the CalTech scientists that the Navy meant to develop NOTS on an "ambitious scale," and expressed his own personal desire that the activities under the CalTech rocket program be physically transferred to "Inyokern as rapidly as possible."⁴¹ With such a move there would be little doubt but that NOTS would become the prime rocket development center for the Navy at the end of the war.

The CalTech group generally felt that such a transfer would have a disruptive effect on critical programs. It would be to the best interest of the war effort, they contended, for the project to maintain its headquarters in Pasadena and for the bulk of the research and development to be done there. It was conceded, however, that the program would benefit by the transfer of some areas of work, including field testing and development of rocket launchers for aircraft as soon as facilities were provided. This set the stage for the later transfer of work in these categories. As of July 1944 it was estimated that only a small percentage of CalTech personnel would go to work for NOTS under civil service "either now or after the war."⁴²

In the same period (almost a year before the war ended), a guideline was issued by Vannevar Bush on the demobilization of OSRD. In the clear style of Bush memorandums, the first sentence stated, "The OSRD is a wartime agency and will go out of existence at the end of the war."⁴³ The general plan was to have a transition period starting with the end of the war with Germany and ending with the defeat of Japan. An orderly plan of demobilization of OSRD would be developed. But all actions and transfers would be arranged so there would be no delay or interference with projects relevant to the war. The obligation of the scientists to aid the services in the transition was clearly recognized.

Difficulties were experienced when institutions like CalTech tried to prepare for demobilization because plans were tied to an unknown date, the end of hostilities with Germany. Finally an assumption was made, for planning purposes, that the date would be November 15, 1944. This was a wrong assumption. In November 1944, the German Army, rather than being defeated, was preparing for the mighty counteroffensive that was to become known as the Battle of the Bulge. There was much deadly fighting ahead.⁴⁴

The view of the Navy toward the demobilization of OSRD was expressed to Bush by Rear Admiral Julius A. Furer, Coordinator of Navy Research and Development, who wrote that "any abatement of interest and active participation . . . of your organization will delay the

final victory over Japan, and will therefore also result in additional loss of life in our forces.”⁴⁵ This message was not lost on the scientists. At CalTech, as elsewhere, the effort was continued through the end of hostilities with a notable shift from research to these projects with a reasonable hope of having a tactical impact.

Besides the individual plans for transferring different OSRD facilities and programs to the services, a plan was implemented to develop a successor agency to OSRD for planning long-range participation by civilian scientists in militarily related research. On June 22, 1944, the Secretaries of War and the Navy established a Committee on Postwar Research under the chairmanship of Charles E. Wilson, Vice Chairman of the War Production Board.⁴⁶

But it would be a long time before the actions of the Wilson committee would have any effect on NOTS. In the fall of 1944 it was becoming clear that the biggest problem in planning the transition would be in getting qualified technical people to take civil service positions and move to the yet untamed desert.

Among NOTS and CalTech personnel it was generally agreed that the transfer of CalTech personnel to civil service could best be done by groups, rather than individually or waiting until all transfers could be made at once. Many problems were met by getting individuals to transfer at the time of the transfer of the function. In general this was done with the understanding that the individual was not committing himself beyond the war. Not the least of the problems in persuading people to transfer was in convincing them of the permanency of NOTS and relieving concerns about military restrictions on their approach to the technical work.

Thompson's proposals for the new research and development organization helped diminish these concerns. By March 24, 1945, he had pulled his findings together in a report addressed to Berroughs.⁴⁷ The technical programs would be under the Director of Research, Development, and Test, who would report directly to the Commanding Officer. There would be two technical departments: one covering research and development under a scientist, and one covering field operations (testing) under a naval officer.

In presenting the plan, Thompson stressed the importance of inducing as many CalTech personnel as possible to transfer to civil service to “carry over a smooth-running and effective organization.” He added, “It is of great importance that Civil Service authorities understand the special nature of the problem of transferring the group... it is hardly in the Government's interest to follow

interpretations of Civil Service regulations which would in effect deny suitable professional or sub-professional appointments because of some arbitrary measure of eligibility.”⁴⁸

Part of Thompson’s concern centered about the necessity for strong scientific direction of the technical programs at NOTS. He not only pointed up the need, but proposed an appropriate candidate as “Director of Research, Development, and Test” essentially the head of the entire civilian scientific organization. The candidate was Dr. L. R. Hafstad who, with Dr. M. A. Tuve, had led OSRD’s highly successful proximity fuze program sponsored by the Bureau of Ordnance. In the March 24 report, Thompson presented the basis for his recommendation:⁴⁹

... If it should develop that Dr. M. A. Tuve, with whom Dr. Hafstad is now associated, should eventually become Director of the Naval Ordnance Laboratory, Washington, or should continue to direct the present Bureau Research Organization which he heads, the distinguished research team of Tuve and Hafstad will then continue to serve the Government and the nation in perhaps the most effective manner possible, namely that as cooperating heads of two great ordnance laboratories operated by the Navy. This will inevitably insure the close collaboration of the two laboratories in the ordnance development field and in the long-range planning which is so essential.

As a significant afterthought, Thompson added:

If the Bureau of Ordnance and the Commanding Officer, NOTS, Inyokern, so desire, I shall continue spending as much time at the Station as possible in an effort to maintain the Director’s office until Hafstad can go to Inyokern on a part or full time basis.

In recommending Hafstad to head the civilian scientific organization, Thompson was saying that the technical effort at NOTS should be under the direction of a scientist of stature. He felt this was particularly important because the prominence of the senior scientist would be of concern to scientists and engineers contemplating employment at NOTS. But Hafstad did not accept the position; instead, Thompson filled the post temporarily until he accepted a permanent appointment some months later.

Thompson also knew that if NOTS was to have a first-class civilian scientific team, the social climate should not be dominated by a military system of rank. From his years at Dahlgren and his inputs from CalTech, Thompson made some practical suggestions pertinent to achieving a harmonious military-civilian relationship:

1. Class distinctions should be avoided if possible. To a Navy man and to many civilians... this point will seem over-stressed. But I believe the present plan will fail in the long run to reach anything approaching its possible success if the question is not dealt with in pioneer fashion (for a

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military station). Most able scientists and engineers, young and old, will dislike staying in a small community where distinctions as to qualifications for quarters, club membership and social privileges are made on the basis of rank. It is not sufficient in dealing with this problem merely to try to line up the civilian technical group according to some formula of rank. While scientists do often enjoy setting up their own ranking systems, they will not accept one which denies full recognition to young men (of outstanding ability and achievement) merely because they are young.

2. Where limitations are necessary in respect to club privileges and other measures of social standing, a careful attempt should be made to find a suitable index of eligibility... [A group of senior civilians and officers] should study exhaustively the problem of removing the causes of uncomfortable feelings as they often exist in communities of officers, civilians and enlisted men...
3. Administrative officers (Navy and civilian) should agree to avoid practices which tend to set up different administrative action covering civilian and military privileges. Most examples of cases which could be cited would be considered trivial but they are, as much as anything else, what leads to bad taste and a desire to get away from a military community...

The prescient thoughts expressed by Thompson on how to achieve harmonious military-civilian relationships were slow to be acted upon. After all, as he himself had pointed out, the "difficulties... have been so far occasionally apparent." And at this time, in the spring of 1945, little difficulty existed at the local level largely because of the example of a personable Commanding Officer who appreciated the need for harmony as much as did Thompson. The few difficulties that did arise were sometimes laughed away. For example, Dr. Fowler reported to Burroughs in a staff meeting that as a civilian he had been unable to get a haircut on the Station. In looking at the scientist's premature sparsity of hair, the staff saw more humor than seriousness in the situation. But it should have been clear that the man who could not get a haircut in town was obviously not part of the community.

The Thompson proposal on how to organize NOTS was unique in its time. In contrast to the prewar organization of naval proving grounds, it called for civilian scientific direction of the technical programs, sought scientists of high professional stature, and recognized the importance of avoiding class distinctions between the military and civilians in both the work and social environments. By design, his was a compromise solution in the sense that it blended the qualities of military control and civilian technical direction. It was what most of the scientists to that time, and many of today, would consider impossible: a civilian organization that could function with scientific freedom within the military structure.

When Bush received an information copy of Thompson's proposal, he jotted down a note for his own immediate staff so they

would know that his support of the plan did not mean that he necessarily thought it would succeed. But as the dean of managers of scientists, he did not fully close any door just because of his own personal skepticism. To Thompson he would say, "We support you." To his staff he confided:

Quite a document! I think they may be attempting the impossible, but we certainly will not refuse to aid on that account. The faster they take over the sooner we become relieved. V.B.⁵⁰

President Truman's announcement on May 8, 1945, that the war had ended in Europe signaled the beginning of the transition of ordnance experimental work from OSRD to the military services.

On May 29 Admiral Hussey affirmed that "The transfer of rocket development from other activities to this Station has already commenced and will be accelerated as rapidly as the growth of the Station's facilities will permit."⁵¹

With new facilities being completed every day, the transfer was not long in coming. As indirect and irritating testimony that the desert Station was maturing into a showplace ordnance establishment, Hussey complained that the constantly increasing number of visitors to NOTS was interfering with highly important development activities.⁵²

The discussions on transition culminated in a meeting on June 5, 1945, at CalTech. It was a grand assembly of key figures from the Navy, OSRD, and CalTech.*⁵³ Of those present, the man with the main power of decision was Captain F. I. Entwistle, Director of Research and Development for the Bureau of Ordnance. Entwistle, an ordnance officer acting with the full authority of Hussey on the matter, stated that the Navy had two principal concerns: (1) the transfer of the rocket program to general Navy supervision, and (2) adequate provision for postwar research.

* Present at the meeting of June 5, 1945, on the transfer and termination of OSRD Contract OEMsr-418 were the following:

Office of Scientific Research and Development: F. L. Hovde (Chief, Div. 3, NDRC), B. M. Norton (Tech. Aide, Div. 3, NDRD).

Navy: Rear Admiral R. S. Holmes (Navy Dept. Liaison Officer, NDRC CalTech), Captain S. E. Burroughs, Jr. (Commanding Officer, Naval Ordnance Test Station, Inyokern), Captain F. I. Entwistle (Director, Re, Bureau of Ordnance), Captain J. L. King (Office of the Liaison Officer, NDRC), Commander C. E. Haugen (Officer in Charge, Bureau of Ordnance Design Unit, CalTech), Lieutenant Commander O. H. Peterson (Re, Bureau of Ordnance).

CalTech: R. A. Millikan (Chairman of the Executive Council), J. R. Page (President of the Board of Trustees), C. C. Lauritsen (Director of Research, OSRD Contract OEMsr-418), E. C. Watson (Official Investigator, OSRD Contract OEMsr-418), W. A. Fowler (Assistant Director of Research, OSRD Contract OEMsr-418), W. R. Stott (Assistant Comptroller, CalTech), I. S. Bowen, T. Gardner, W. Huse, R. B. King, W. N. Lacey, T. Lauritsen, F. C. Lindvall, M. Mason, B. H. Sage, W. R. Smythe.

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The plan that evolved set the pattern of the postwar transition. The rocket development and test work would be transferred to NOTS. The rocket production would be picked up under a broad contract with the General Tire and Rubber Company.* The torpedo launching facilities at Morris Dam, along with the associated torpedo programs and underwater studies, would become a substation of NOTS Inyokern. The propellant work and activities at Eaton Canyon would be decreased and eventually closed down as the work was absorbed by the China Lake Pilot Plant.

As to the other major concern, Entwistle summarized the Navy's general position on postwar research: "The Navy," he said, "believes that postwar research involves a two-way responsibility: the Navy's to foster it, the colleges' and universities' to cooperate in it."

J. R. Page stated the position of the CalTech Board of Trustees. The board had been disturbed for some time by the financial magnitude of the work and was eager to get the Institute back to "its normal and proper job of teaching and fundamental research."

Hovde spoke for OSRD, stressing that "Dr. Bush will not approve any projects involving work for the postwar period." Its policy was to press for steady transfer of its activities to the military services until the end of the war. It would agree to the transfer of the rocket program during the next six months.

The following target dates for the transfer were agreed to:

July 15, 1945:	Transfer of rocket production activities to General Tire and Rubber Company
September 1, 1945:	Transfer to NOTS of Morris Dam and its activities
October 1, 1945:	Target date for closing of Eaton Canyon facilities
December 1, 1945:	Transfer to NOTS of the China Lake Pilot Plant and associated activities
December 31, 1945:	Termination of CalTech's experimental work on propellants and interior ballistics
December 31, 1945:	Target date of OSRD for the termination of all its experimental activities related to NOTS with the understanding a review should be made in November to see if some specific projects should be continued into 1946

Thus, the main framework for the transfer was set. It was a plan that paved the way for NOTS to become the leading ordnance research and development laboratory on the West Coast, if not the nation. The professors wanted out; the Navy wanted ordnance

* The General Tire and Rubber Company also picked up another OSRD/CalTech activity. This was the JATO program—development of rocket units for "jet-assisted take-off" of aircraft—that was being done by CalTech's Guggenheim Aeronautical Laboratory (GALCIT). The Institute's small contractor, Aerojet, was purchased by GT&R and later became one of the nation's largest postwar aerospace industries for rocket engines.

experimental work to continue under its direct leadership. In the process, NOTS got the key facilities. But it would take more than facilities to attain an effective research and development center, it would take qualified people and leadership, too.

CalTech was the most obvious source for the new NOTS to recruit scientists, engineers, and technicians with ordnance experience. Many of the candidates had the choice either of seeking employment in new fields or of moving to Inyokern and working for a new employer, the U.S. Civil Service. In the main, the people involved had extremely strong feelings regarding both.

The first choice is not hard to understand as it represented the clear-cut difference in life styles between Pasadena and the remote desert. But joining civil service had other ramifications.

The limitations of the civil service system of that time in meeting the needs of a technologically advanced society were not localized at NOTS. On the contrary, it was a problem that surfaced simultaneously throughout the entire spectrum of the technical and scientific staffs working for the military.

As the struggle widened and intensified, Dr. Hafstad and subsequently the entire scientific fraternity of the American Physical Society joined the fray. It was only after the establishment of the Office of Naval Research in 1946 and the Atomic Energy Commission in 1947 that sufficient leverage could be brought to bear on a reasonable resolution of the civil service classification problem.

Basically the problem stemmed from an obsolescent civil service classification system that was not applicable to a modern technical establishment. Classification standards did not exist for many of the professional and technical positions. Classifiers were required to follow hard and fast rules. Final classification authority was held by persons remote to the laboratories. The local position descriptions had to match the inadequate classification standards in order to determine the civil service ratings that in turn would determine what salary would be paid. Although the system had worked for artificers and artisans, it was woefully inadequate for scientific and technical people.

The classification problem proved to be a particularly obstinate one for NOTS when it took over the technical leadership of ordnance programs from CalTech. Up to this time the Station had few civil service employees, and these did not include many senior scientists and top-level supervisors. The problem became obvious when the attempt was made to influence senior CalTech people to transfer to NOTS and civil service. Not only were they concerned with what

they perceived as the immediate humbug of wrestling with position descriptions to obtain the proper grade and salary level, but more important, they were apprehensive as to whether civil service bureaucracy coupled with military command would restrict their approach to the technical work. Accordingly, most of the professional staff declined offers of civil service careers at Inyokern.

However, the Station was fortunate that a nucleus of CalTech personnel did sign up, thus ensuring some continuum of civilian technical personnel with experience in rocket and torpedo work. Burchard points up one group in particular:

...most of the 200 members of the Inyokern Range Operations Group...under Dr. Ellis, accepted Navy Civil Service appointments. This group was transferred, not only for the purpose of operating the test ranges on the Station, but also to serve as a nucleus for the growth of the Research and Development Department...⁵⁴

The reaction of Duane Mack, who like Ellis had come on board with the first NOTS test, provides insight as to why persons who were deeply involved at the NOTS site were more likely to stay on under the new structure than others:

Well, I was extremely interested in the aircraft ranges. It was fascinating because I'd been out here from the very beginning and they were building up and they had developed to quite an extent. We were getting new facilities and new instrumentation and it was an extremely interesting area to work and I was anxious to see it finished and this was really why I wanted to stay.⁵⁵

But Mack and Ellis represented the minority. Most of the technical staff and the scientific leaders of the CalTech rocket program were preparing to leave the ship as soon as they heard the victory sirens of V-J Day.

Leadership was a key factor needed to assure that the facilities and programs inherited by NOTS would allow it to become an effective postwar research and development laboratory. Here too there were potential problems. We have seen the difficulty in obtaining a permanent civilian director for the technical effort. Warnings of a further problem had emerged as early as September 1944. At that time Thompson had written to his old friend Parsons as follows:

Captain Burroughs was here [NOP Indianapolis] for a day last week and I talked with him about some of his problems. I think he is making excellent progress and he had some very good ideas if they can just be crystallized in such a form [that] they will not be dropped when he leaves. He is already talking about wanting to get back to sea. There are now about 7,000 men working on the building program. It is going to be a magnificent plant, the sort of place we always dreamed about but never expected to see. I think the most important point right now is to see that the right successor to Captain Burroughs is selected.⁵⁶

Burroughs, too, was concerned about "the right successor." Perhaps he more than anyone in CalTech or the Bureau of Ordnance was keenly aware of the rather special qualifications required of any man at the NOTS helm. After all, Burroughs not only was the helmsman but had also been one of the principal architects of the desert ship and knew well her sailing characteristics. As the time to rejoin the Fleet drew closer, Burroughs wrote regarding the opening at NOTS to a friend, Captain David B. Young, who occupied the desk for Aviation Ordnance in the Bureau of Ordnance, Burroughs' desk before he took over command of NOTS. Young replied:

Dear Evvie:

Suppose you think I have been ungrateful for your offer relative to Inyokern. Let me assure you that I appreciate your considering me. Had it been six months or a year ago, I should have fought for it because it is exactly the kind of work I have always wanted to do. Had understood that Admiral H. [Vice Admiral G. F. Hussey, Chief of the Bureau of Ordnance] had given a down on your proposal. However, a few days later Admiral K. [Rear Admiral W. A. Kitts, Assistant Chief of the Bureau of Ordnance] asked me if I should like to relieve you. Told him I was flattered by the offer but felt that I was in a bad position on sea duty and should prefer a sea command if I could get away. I asked for a day or two to consider. On Windy's [Captain (later Rear Admiral) Wendell G. Switzer] advice, I saw Rev. Meadows [Captain H. L. Meadows, Detail Officer for the Bureau of Aeronautics], who literally [sic] "hit the roof." He said I needed the sea duty and, besides, I was too junior for the job. Said he would oppose my getting it. He could promise me no CVE command. So you see, I was pretty much in the middle. I have told BuOrd I want to go to sea so they have OK'd getting in a relief for me. Again let me thank you for recommending me for this job as you did for the original AAU. Hope that some day we can "click."⁵⁷

Burroughs wrote to others whom he thought would be in tune with the NOTS concept, but in the end he had no influence on the selection of his successor.

In the meantime Burroughs was being urged by his associates to reconsider. Particularly vociferous in these attempts were CalTech leaders Lauritsen, Fowler, and Ellis. His naval comrades in the persons of Hayward, Pollock, Duncan, and Richmond also asked him to reconsider, but as naval officers they would understand the explanation he later gave.

My turn had come up to get command of a ship. I wanted to get back into the war, a little more closely into the war. My orders were issued—I guess—about April of 1945 to go out and command a ship. When there is a war going on I guess probably every man who has made a career of the military wants to be out there to fight the war. . . .⁵⁸

Although the reasoning was understandable, the common point of view at NOTS was that the impending departure of the popular

and able Commanding Officer was untimely. It became increasingly clear Burroughs would be leaving just as the problems of transition from a wartime station to a peacetime research and development center under Navy management would come to a peak.

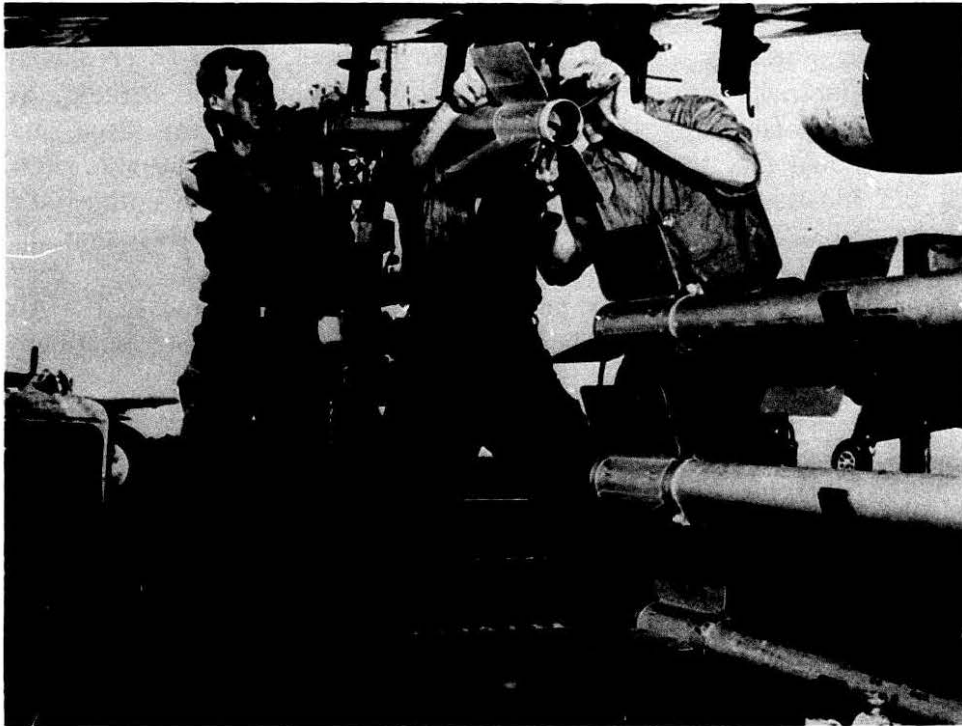
Despite the long planning for the transition to peace, the end of the war would find NOTS facing dilemmas in recruiting a qualified professional staff, in obtaining a leader of stature for the technical programs, and in losing its Commanding Officer at a critical hour of need.

INYOKERN: THE WAR CONTRIBUTION

It is logical to expect that the history of NOTS during World War II include a summary to show the direct contribution of the Station to the war effort: a sort of balance sheet of accomplishments to validate the terms of the charter, "research, development, and testing of weapons." Such a balance sheet is difficult to construct and even harder to interpret. For example, how does one assess the contribution of the early Fleet training achieved at Inyokern? Proficiency in the combat use of rocket weapons surely must be as important as the weapons themselves. Yet, it is the hardware that is most often associated with the NOTS wartime effort: Holy Moses, Tiny Tim, spinners, fuzes, warheads, launchers, and rocket sights.

The retrospective story of how these weapons went to war shares equal significance with that of their actual deployment in the combat theaters of Europe and the Pacific, as it strongly points up the fact that ordnance problems do not necessarily end with the completion of development; rather, they extend deeply into the phase of introduction into service. There is irony, too, in the story in that Holy Moses—a rocket developed for the Navy—was first used in combat by the U.S. Army Air Corps.

Retributive justice would have been served indeed if the launching sites of the new German secret weapon, the V-1 flying bomb, known as the buzz bomb, could have been demolished by this newest of the U.S. rockets, the 5-inch HVAR, Holy Moses. This was the objective in the summer of 1944 when a special mission was set up for equipping and training an Army Air Corps squadron with Holy Moses rockets.



Courtesy National Archives

The 5-inch HVAR for the Fleet being loaded on zero-length wing launcher of F6F fighter aircraft.

By contrast with the fumbling efforts that sometimes characterized the introduction of new weapons into service use, this effort was capably handled. An experienced group of military officers and scientists went to a base in England to indoctrinate the 513th Fighter Squadron, 406th Fighter Group, Ninth Air Force, in the use of these rockets that as yet had not been baptized in battle. The mission included Lieutenant Colonel Harry F. Donicht, head of the Aircraft Section of the AAF Material Command, other military and technical representatives from Wright and Eglin Fields, Royal Air Force Group Captain H. W. "Dixie" Dean, and one of the leading CalTech scientists, Dr. Carl D. Anderson. Dr. Lauritsen was also officially on the mission, but a V-2 rocket had crashed in Sweden just as he arrived in Europe so he went there to take advantage of the unique opportunity to gain first-hand technical knowledge of this large German rocket.

According to Hayward, it was Lauritsen who really interested the Ninth Air Force in CalTech rockets. To this end, Lauritsen employed his personal friendship with Generals Vandenburg and Arnold, as described by Hayward, "... Charlie Lauritsen could go any place, and people would talk to him... he knew all the chiefs and he also knew all the Indians." According to Hayward, Lauritsen, while enthusiastic about a weapon to hit the V-bomb sites, was also convinced that the Navy rockets could kill tanks, railway rolling stock, and road transport vehicles; ultimately he was similarly able to convince the Air Corps general staff. In this he was aided by a general disenchantment by the Air Corps with their own 4.5-inch aircraft rocket.⁵⁹

The introduction of Holy Moses into service was so closely phased with the first production of the rocket that 100 rounds a day, manufactured under CalTech direction, were ferried daily by air from California to England until 1,400 of them were delivered.⁶⁰ Dr. Thomas Lauritsen, Charlie Lauritsen's son, was at Pasadena to see that the shipments went as scheduled.

This effort did not pay off where originally expected, but elsewhere. By the time the launcher installation and the training of the 513th pilots were under way, the Germans had changed their tactics of firing the V-1 bombs from permanent sites and were using mobile pads that were frequently moved to make detection and attack more difficult.⁶¹

Although Dr. Anderson recalled that the change of mission was due to the German adoption of the mobile V-1 launch pad, Burchard states that there was "[doubt] whether the rockets would be able to do any significant damage to the launching sites; as these proved to be so sturdily built of reinforced concrete that they could withstand even heavy bomb hits."⁶² This reasoning would explain the high British interest in Tiny Tim in June 1944. More probably, the shift was due to mission priority: British antiaircraft gunners with the new proximity-fuzed shells were proving that they could cope with the V-1 threat; there was an urgent need to stimulate the stalled momentum of the Normandy invasion.

Consequently, the squadron's mission was shifted away from the V-1 sites to help the stalled Allies push out of the Normandy beachhead. On July 15, 1944, the squadron, flying P-47 Thunderbolts from England, struck targets in the Saint-Lô area.

The pilots were operating under two handicaps. Their training was limited, particularly in actual firing of the precious rockets, and the Thunderbolts had only four launchers instead of the eight

normally installed on Navy planes. Despite these limitations, they made the introduction of Holy Moses into battle an occasion not to be forgotten by the enemy.

Reports of the results varied as to details, but all agreed that a large number of targets were damaged by the rockets. Anderson's notes made from interviews with pilots returning from thirteen missions indicated 13 tanks destroyed, 2 probably destroyed, and 10 others hit; 1 pillbox hit, and 5 trucks and 2 armored cars destroyed. In these actions two aircraft and one pilot were lost. The official Bureau of Ordnance administrative history reports that the 513th's main action was in support of General Patton's tank columns in their famous breakthrough at Constances in the Brittany Peninsula, July 26 to 29, 1944. And the squadron played a key role in halting a heavy German counterattack on August 9 from Vire and Mortains toward the sea.⁶³

Aside from the tactical results, it appeared initially that the experience of this one squadron would have a great impact on the Air Corps' future plans for rockets. Lieutenant General Carl Spaatz, Commanding General of the U.S. Strategic Air Forces in Europe, wrote, "The success of the equipment has resulted in a requirement from the Ninth Air Force to equip all of their P-47 fighter aircraft with rockets."⁶⁴ Major General E. R. Quesada, Commander of the Ninth Air Force (in requesting thousands of the rockets by TWX), reportedly dictated, "We want CalTech rockets, repeat, we want CalTech rockets, not Army Ordnance."⁶⁵ Also characteristic of the reaction was the statement by Major General B. E. Meyers of the Air Technical Service Command, who described the Holy Moses as the "best anti-tank weapon of the war."⁶⁶

With aircraft rockets in the spotlight at the start of the push across the continent toward Berlin, it could be expected that the demand and use would be accelerated, as in the Pacific. But such was not the case. Several explanations have been given. The success of one combat fighter squadron's minimal training had given rise to a belief that there was no critical need for training in the use of this quite different type of weapon. Overlooked was the fact that the 513th was an exceptional squadron. The method of supply for the 513th was also exceptional. The follow-up squadrons did not have the personal attention of a Tom Lauritsen in the States. In the upgrading of rockets and launchers, the rockets for one type of launcher often went to squadrons equipped with other launchers. There were no scientists like Carl Anderson or technically knowledgeable officers like

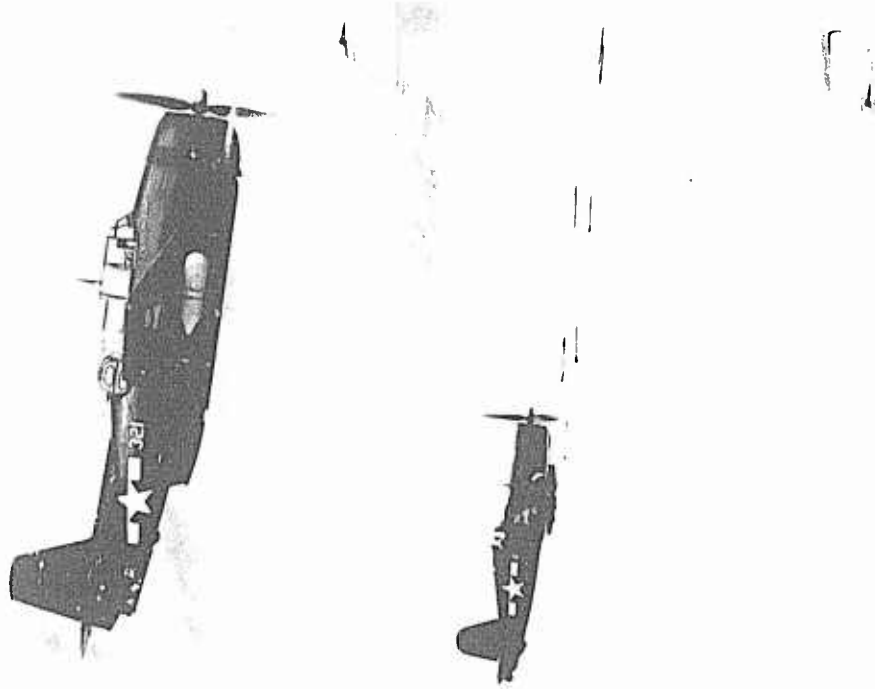
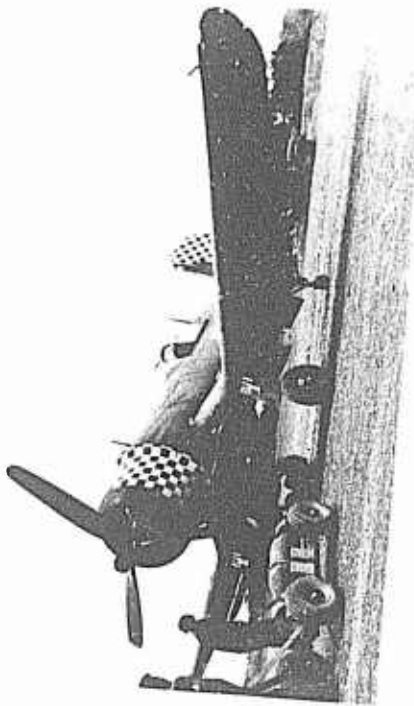
Harry Donicht around to give technical direction when needed. And there were no well-prepared operational manuals. These shortcomings gradually led to a growing body of disappointment in the use of rockets by the air forces in Europe. The Holy Moses rockets fired by P-47s helped break a German counteroffensive in August 1944, but otherwise these and other rockets played only minor, sporadic roles in the final rollback of the German army.⁶⁷

It was quite a different story in the Pacific. There, the war was essentially a naval war. The naval officers and the scientists associated with the Navy-sponsored rocket projects could carry their message to every level in the combat theaters, from the Commander in Chief, to the logistical support groups, and the sailors and marines loading the launchers. Once rockets had proven themselves in battle, the contacts between the operating forces in the Pacific and the CalTech scientists became a firm and fast relationship.

When W. A. Fowler toured the Pacific combat arenas in the spring of 1944, rockets were fast becoming major weapons of war. By the end of hostilities their use was extensive. The Army was procuring rockets to the tune of \$150,000,000 a year. The Navy had 1,200 war plants in a program for turning out rockets at eight times this amount.⁶⁸ The Navy's expenditure for rocket weapons in 1945 was \$100,000,000 *per month*.⁶⁹ From the standpoint of production and the rapid refinement of combat doctrine, it can be concluded that if Japan had been invaded, the rocket power released would have been phenomenal.

Following its introduction to the Fleet in December 1944, Holy Moses served (as had its predecessors, the 3.5- and 5-inch ARs) by inflicting death blows to Japanese transports, knocking out antiaircraft-gun emplacements, and blasting away heavy defensive fortifications. Only a few months earlier, Fowler had been aware of the promises offered by the aircraft rocket in combat. And these promises were fulfilled. Zero-length launchers, improved fuzes, efficient rocket sights—all had helped to bring even the earlier weapons closer to their full potential. Holy Moses was a quantum leap forward in exploiting this potential where it counted—helping to break the back of enemy resistance to our massive offensive by land, sea, and air.

Tiny Tim barely made it into combat, the late coming being typical of the fortunes of war. Like Holy Moses, it had been initially planned for use against the launching sites of the German V-weapons



During April-June 1945 forward-firing rockets were used extensively by Marine Corps combat aircraft against Japanese stronghold, on Okinawa.

Courtesy Headquarters, U.S. Marine Corps

in occupied France. Accordingly, for a short time, Tim enjoyed a maximum priority.

But again, like Holy Moses, the reason for its not being used as planned was the same: the need to destroy the launching sites diminished as wartime conditions changed. Antiaircraft fire, enhanced by the SCR-584 radar, the M-9 director, and the proximity fuze, was able to counter the airborne V-1 bomb, and the timely capture of launching sites in the European coastal areas decreased both the V-1 and V-2 threats. Hence, the priority for Tiny Tim was downgraded. Meanwhile, the launcher problems (detailed earlier) were taking their toll in lost time.

In the spring of 1945, F4U squadrons equipped with Tiny Tims were sent out on the carriers *Franklin* and *Intrepid*—part of Task Force 58 commanded by Admiral Mitscher. On March 18, while cruising in Japanese waters some 40 miles offshore, the *Franklin* became a target for air attack. A twin-engine Mitsubishi bomber unloaded two 500-pound armor-piercing bombs that penetrated the carrier's flight deck and exploded against the hangar deck. On that deck the F4U aircraft were loaded with fuel and Tiny Tims with high-explosive warheads; 14 Tiny Tims were set off by the flames, adding horribly to the holocaust.

Tiny Tims from the aircraft of the *Intrepid* were used in the battle of Okinawa in April 1945, but it was difficult to make any useful evaluation of their effectiveness because of the overwhelming bombardment from a wide variety of ordnance. But Tim made it to the war. Had the war not ended before it became necessary to invade the Japanese home islands, Tiny Tim would have been ready, not only for Navy use, but also for the Army Air Forces, which in late 1944 were preparing planes and pilots for deploying "the really big rocket." In his work, *Rockets, Guns and Targets*, Burchard includes a significant footnote: "The war ended before the most formidable rocket plane got into action. This was the F4U equipped to carry eight 5-inch HVARs and two Tiny Tims—a total of 3800 pounds of potential destruction." In yet another footnote, he mentioned that there were more than a million HVARs stockpiled at the close of hostilities.⁷⁰

Thus, a weapon with the Inyokern stamp was scheduled for mass delivery to the homeland of the enemy. But the course of events dictated otherwise. Another new weapon of war that CalTech and NOTS had been involved with, the "really big" one—the atom bomb—brought the war to an end without the need for an invasion.

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- NA National Archives, Washington, D.C.
- OA Operational Archives, Washington, D.C.
- CTA Library Division, Archives, California Institute of Technology
- URCB Naval Weapons Center records stored at Federal Records Center, Bell, California

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6

CAMEL and Salt Wells

Some activities of wartime NOTS stood apart from the primary role of developing aircraft rockets. The most significant of these activities was an involvement with the nation's supersecret atomic bomb program.

During the spring and early summer of 1945, a new facility was built at Inyokern—a pilot production facility that fabricated nonnuclear explosive components for the new weapon.

The Salt Wells Pilot Plant was swept into existence by a surge of effort to bring the war in the Pacific to a close and so to forestall the costly necessity of invading the Japanese homeland. Yet, it was the long-range permanence built into this plant that helped to flesh out postwar ordnance research and development during the difficult years of peacetime adjustment.

PROLOGUE TO VICTORY

Captain William S. Parsons arrived at Inyokern on Wednesday, July 18, 1945, for a brief visit with Lauritsen and Burroughs. The calmness he showed in discussing the NOTS work and in reporting the first A-bomb test at Alamogordo two days earlier was typical of Parsons. It is a matter of speculation as to whether he told these two close associates that he was on his way to a very select Pacific island and that he had been chosen to be the weaponer in charge of the tactical delivery of the first atom bomb.

THE GRAND EXPERIMENT AT INYOKERN



Courtesy Los Alamos Laboratory

Rear Admiral William S. Parsons, ordnance pioneer and staunch friend of NOIS.

Parsons was one of the last of the team to arrive at Tinian, approximately 1,450 miles from Tokyo. Work had begun there in February 1945 to construct the supersecret base. It was now the middle of July, and the B-29 bombers and men of the 509th Group had arrived. The gun type nuclear bomb (Little Boy)—as yet an untried weapon—arrived on July 26 aboard the cruiser U.S.S. *Indianapolis*.

Captain Parsons, whose responsibilities at Los Alamos, New Mexico, had been to make the bomb a deliverable weapon, was personally assigned by Major General Leslie R. Groves, USA, top man in the Manhattan Project, to be in charge of the bomb on the epoch-making flight of the *Enola Gay*. In these words Parsons described the impact of the first atom bomb, which was dropped on the city of Hiroshima on August 6:

It was a terrific spectacle. The huge dust cloud covered everything. The base of the lower part of the mushroom, a mass of purplish-gray dust about three miles in diameter, was all boiling—the entire area was boiling. A huge white cloud got separated from the top of the mushroom and went upward. Then a second white cloud rose into the air and started chasing the first one. . . . The purple clouds and flames were whirling around. It seemed as though the whole town got pulverized.

If the Japs say a meteor hit them, we can tell them we have more where this one came from.¹

While preparations for deploying a second bomb were under way, millions of leaflets were dropped over Japan. The text was direct:

TO THE JAPANESE PEOPLE

America asks that you take immediate heed of what we say on this leaflet.

We are in possession of the most destructive explosive ever devised by man. A single one of our newly developed atomic bombs is actually the equivalent in explosive power to what 2,000 of our giant B-29's can carry on a single mission. This awful fact is one for you to ponder and we solemnly assure you it is grimly accurate.

We have just begun to use this weapon against your homeland. If you still have any doubt, make inquiry as to what happened to Hiroshima when just one atomic bomb fell on that city.

Before using this bomb to destroy every resource of the military by which they are prolonging this useless war, we ask that you now petition the Emperor to end the war. Our President has outlined for you the thirteen consequences of an honorable surrender. We urge that you accept these consequences and begin the work of building a new, better, and peace-loving Japan.

You should take steps now to cease military resistance. Otherwise, we shall resolutely employ this bomb and all our other superior weapons to promptly and forcefully end the war.²

THE GRAND EXPERIMENT AT INYOKERN

One more bomb was "resolutely employed" against the Japanese town of Nagasaki on August 9, 1945. As with the Hiroshima attack, the weaponeer aboard the B-29 aircraft was a naval officer Commander (later Vice Admiral) Frederick L. Ashworth.* This bomb was the implosion type (Fat Man), but its tremendous power for destruction was the same as had been demonstrated by the first; this was enough to cause Japan to surrender. On August 14, the allied terms of capitulation were accepted, thus ending one of the bloodiest wars in human history.

As to a report on one of the most unusual missions a naval officer ever had, Parsons summed up the delivery operations of the bombs with this simple observation, "Once in many centuries you can't shake off the Midas touch. That's what happened to us."³

Among the questions Groves was asked at the end of the war, one had particular significance to NOTS: How many bombs were available to back up the "warning to the Japanese people"? His answer was always, "Enough." Although in terms of immediate availability there were probably fewer than a half dozen, Groves' single-word answer had much wider implications. Los Alamos was still geared to a high degree of operational readiness, and the brand-new plants at Hanford, Washington, and Oak Ridge, Tennessee, were staffed and equipped to produce nuclear materials in quantity. And at Inyokern, California, the paint was hardly dry on a permanent facility called the Salt Wells Pilot Plant. On July 25, the first high-explosive blocks had been melted, poured, and cast. Had the pressures of continued war been maintained, volume production of these vital components for atomic bombs could shortly have been available and flown immediately to a selected assembly point. Thus, in the not too distant future, there would have been a steady and devastating supply of the new weapons to underscore their most significant aspect: the most powerful deterrent force against future wars ever held by a nation.

The total picture of the nation's A-bomb production resources poised in readiness, some of them as yet untapped, makes it easier to understand that the warning to the Japanese people had not been a precarious gamble based on the immediate availability of two bombs.

It also helps us to comprehend the story of the Salt Wells Pilot Plant at NOTS: its existence, its purpose, and its role in the future.

* This officer has a special place in our history as he served as Commander, Naval Ordnance Test Station, China Lake, from 1955 to 1957. He was both an ordnance postgraduate and a naval aviator.

For although the plant was conceived and built for war, its greater purpose would be achieved in peacetime by helping to provide the nuclear deterrent power of the nation in the postwar period. To this end, activities at Salt Wells continued to flourish under the stimulus of priorities and funding initially from the special project set up under the purposely misleading title of Manhattan Project, then eventually from the Atomic Energy Commission.

In addition to producing explosive components for nuclear weapons, the desert facility exercised to the fullest its pilot plant function, providing the "know how" necessary for setting up industrial production plants and pointing the way to more efficient production by these plants.

In these ways the Salt Wells Pilot Plant of NOTS helped assure in the years to come that when the question of sufficiency in the A-bomb inventory arose, there would be no doubt about the substance of the word, "Enough!"

THE LOS ALAMOS CONNECTION

When the histories of certain wartime research and development centers are arrayed side by side, one is often immediately impressed by the similarity; almost as if a master scenarist had devised the same scenario for each. This is particularly suggested by the early histories of NOTS and the atomic research laboratory, then known as the Manhattan Project, at Los Alamos, New Mexico.

Although Los Alamos was started exactly a year before NOTS (at the end of 1942) and despite the differences in their products (NOTS, the aircraft rocket; Los Alamos, the atom bomb), their respective stories have identical elements: selection of a remote site; incredible construction achievements in a short-time framework; the overwhelming difficulties caused by the early, near-primitive living and working conditions; the problems of a military-civilian community; the desperate urgency of the program imposed by the nation's military needs; and a shortage of labor and materials. These latter problems were more than mere reflections of those of Los Alamos; they were largely caused by the draining of the labor pool by the highest-level priorities of the New Mexico facility. Similarly, when building materials and special-purpose scientific instruments were not available for NOTS, there was a strong chance that Los Alamos had gotten them first.

But aside from the similar elements in their early histories, NOTS and Los Alamos were closely related in other ways. Despite the fact that the military jurisdiction in each case was quite different, the development programs for the main products involved at both facilities were under the management of civilian universities. Just as CalTech was the scientific overseer of the rocket programs conducted at NOTS, so was the University of California for the weapon project at Los Alamos. The respective scientists of these sister academic institutions (both based in California) shared common interests and were well known to each other. Some had even taught at both schools. Dr. J. Robert Oppenheimer was one of these. For twelve years, long before he became Director of the Los Alamos laboratory, he served as assistant professor, alternating between CalTech and the University of California at Berkeley. "Oppy" and "Charlie" Lauritsen were former colleagues. In the fall of 1944 Oppenheimer contacted his old friend and asked him to help them out at Los Alamos. Lauritsen had been approached (probably through James Conant, Chairman of the National Research and Development Committee) some two years earlier when Los Alamos was being started, and a general recruitment of scientists was under way. At that time, however, Lauritsen and CalTech were deeply embroiled in the new rocket program. In October 1944 things had changed. The rocket program was in full swing at Inyokern; Lauritsen could consider part-time work with Los Alamos in a much more favorable light.

The A-bomb developers needed a lot of help in their program, the most complex and challenging in the history of science and ordnance. Although the tremendous potential release of energy through the splitting of the atom was real in the minds of the theorists in the prewar years, its practical accomplishment in the form of a deliverable weapon was a long way off. The gulf between theory and hardware had never been so wide.

Reduced to basic fundamentals, the first method of achieving nuclear fission was by using a gun to fire one subcritical mass of fissionable material (uranium 235) into another in order to form a critical nuclear mass that would explode instantaneously. There were a host of major technical problems, but the most formidable one by far centered about the U-235 nuclear material itself. Due to the slow, painstaking process of separating this material, there would be enough to make only a few bombs. An alternative material, plutonium, could not be used with the gun method. However, it could be used by employing the implosion method, in which a sphere was made of high

explosive. When detonated at the periphery, the blocks of high explosive focused their shock waves inward onto a core of nuclear material, causing it to reach the critical density under the new pressure condition.

Indecision as to whether to use the gun or the implosion method reached crisis proportions during the Manhattan Project's development program. Later on it was decided to develop bombs using both methods. Because of its unsurpassed leadership in the field of guns and projectiles, the Bureau of Ordnance assumed a major role in the design of the very special "gun" required for the A-bomb. Development of the bombs by the implosion method was to involve Lauritsen and his associates because of their expertise on two of the design problems.

The first problem stemmed from difficulty in finding a reliable detonator with an action that was fast enough a fraction of a millionth of a second. Each bomb required a detonator to initiate each geometrically shaped, high-explosive block surrounding a nuclear core. This action had to be within microseconds as nearly simultaneous as possible. Through the efforts of C. C. Lauritsen and his CalTech scientific staff, appropriate detonators were designed. Lauritsen's close association with NOIS paid off as equipment, facilities, and security were available at Inyokern for the development testing of these detonators, which were known as "sockets." Development and testing of the sockets were under the direction of William Fowler and Thomas Lauritsen, and while the program was not strictly within Bruce Sage's principal area of responsibility, China Lake Pilot Plant facilities were used to load and test-fire the detonators, which were made in Pasadena.

The other problem was infinitely more complicated and concerned the intricate high explosive blocks themselves: their process, manufacture, and test.

The scientists and technicians of Los Alamos pioneered the initial process. The explosive was cast to a uniform density in specially designed molds, and then the cast blocks were carefully machined into the required shapes. Machining explosives was virtually a new technique, and the military and civilian machinists, for the most part, had to teach themselves. The fact that they mastered the art in such an incredibly short time is almost beyond comprehension. But their deadline to have the first bomb ready was immutable. The fate of nations was at stake.

In late 1944 the conditions at Los Alamos for making precise

high-explosive components were anything but ideal. General Groves described them in a later interview:

We have built at Los Alamos what was called the "S-1", it may have been "S", an explosive plant. [It was "S-Site," named for a sawmill that formerly stood there.] At any rate, this was a most dangerous plant. It was like one of these firecracker plants that you read of blowing up every once in a while. We only had two people out there who knew anything about the manufacture of explosives. One was a foreman that we got from Army Ordnance, and he was a crackjack; he knew that everything there was most hazardous. The other one was an enlisted man, a chemist who had, I think, been with Hercules Powder in the production end. He was absolutely horrified when he saw how we were operating. I knew quite a bit about it because I had been building ordnance plants and knew what precautions should be taken.⁴

Groves shared his concerns about S-Site with the quiet-spoken Navy captain who headed up the Ordnance Division at Los Alamos, W. S. Parsons. According to Groves, it was "Deak" Parsons who suggested the need for another high-explosive plant. It was also Parsons who involved NOTS in the Manhattan Project in the first place, and who later drew the Bureau of Ordnance into the new field of nuclear weaponry.

Parsons did more than merely suggest the need for another high-explosive plant. He also passed along some thoughts as to where such a plant might be located namely, the Naval Ordnance Test Station, Inyokern, California. The NOTS site was remote and relatively easy to secure; and security was an abiding passion with General Groves. Also, CalTech was inseparably linked to NOTS and it was the Institute's expertise that was essentially solving the thorny problem of high-explosive lens design. Moreover, CalTech had considerable experience in building and operating ordnance plants: for example, Baton Canyon and the China Lake Pilot Plant.

Groves seemed to have had some mixed feelings about having the plant under Navy command. The Navy's views on safety were considered by Groves to be too stringent in what were termed "the normal ammunition lines." In his eyes, his program was anything but normal and should not be inhibited by "the conventional lines of safety." As he stated in a later interview, "I ignored most of [the conventional lines] deliberately. It wasn't a case of not knowing any better or being reckless, or anything like that. It was just a cold-cut decision that it was worth taking a chance on...remember, time was all important to us."⁵

Misgivings notwithstanding, Groves made another characteristically cold-cut decision on January 1, 1945. On this day, he and Parsons flew to Pasadena to meet with Lauritsen and Sage. At the end of the

meeting. CalTech and NOTS had acquired another heavy, albeit highly interesting, burden: the building and later the operation of a pilot plant for the nonnuclear explosive components of atom bombs.

A NEW PILOT PLANT

At first glance, the bustle of construction activity in February 1945 seemed like an uncanny replay of the events that had taken place almost exactly a year earlier when the China Lake Pilot Plant was built: an army of bulldozers and earth-moving vehicles gouging the rocky, sloping sides of the Argus Mountains, spreading from the foothills down to the floor of the Salt Wells Valley—an expanse of white alkali comprising the bed of an ancient lake. Here would be built the new pilot plant needed for the Manhattan Project; it would be named for the Valley.

Adjacent to this new site and barely discernible through the clouds of dust hanging in the cool air of the Mojave spring was the China Lake Pilot Plant. Although this particular facility was started more than a year before, it was still far from complete. Use of the 12-inch press line for the production of rocket propellant had just barely begun.

The principals in the new venture were the same: CalTech and the Bureau of Ordnance. Even the same people were involved: Dr. Bruce Sage and Dr. William Lacey of CalTech; Palmer Sabin and the Institute's engineering design group. The Haddock Engineers construction crew worked according to the plans and specifications of the Holmes and Narver architects and engineers.

On the Navy side, the cast of leading actors had changed somewhat. Captain Moeller had replaced Captain Sandquist as the Bureau of Yards and Docks' man on the job. In the Bureau of Ordnance, Captain Byrnes, the indomitable watchdog of shore establishments, still maintained a wary eye on the construction activity; however, the responsibilities were progressively being shifted to the shoulders of a much younger yet almost as aggressive officer, Lieutenant Commander Dexter Bullard.

But the commonality of the China Lake Pilot Plant and the new pilot plant ends with a similarity of the early construction scene. The Salt Wells story was going to be entirely different. For, despite the fact that virtually the same people were involved in planning the new pilot plant, their attitudes had dramatically changed. From the onset,

both CalTech and the Navy approached the project with a certain "once bitten, twice shy" wariness. Harsh lessons, such as the need to determine safety requirements before pouring foundations, had been learned.

As builder and ruler of the China Lake Pilot Plant empire, Sage was a natural candidate for the job of planning the new plant at Salt Wells. And he approached the task with characteristic gusto. Although he received the word from Lauritsen only a scant 24 hours before General Groves and Captain Parsons arrived in Pasadena on January 1, 1945, by the time of that historic meeting Sage was able to put a tangible plan down on the table for all to study.

In spite of the deadline and a minimum amount of information, Sage had produced a proposal for the new plant. He estimated that the plant and equipment would cost \$13,000,000. Two major factors had to be taken into consideration. First, many of the processes and equipment were technically unique and untried. As it later turned out, even while the plant construction was under way, some of the manufacturing techniques were not yet definitely established. The second factor was one that would not only significantly affect the cost but also tax even the seemingly inexhaustible energies of Bruce Sage. The plant was to be constructed and in operation 100 days after groundbreaking!

Within this period, the building and equipping of the Salt Wells Pilot Plant would have been a remarkable accomplishment if it had been only a moderately sized plant of temporary construction for a well-established manufacturing process. But the plant was extensive; moreover, 52 out of its 80 buildings were of permanent construction.

After the January 1 meeting, activity immediately went into high gear; this was imperative if the 100-day schedule was to be met.

There was a sound reason for the early July deadline. The entire A-bomb development was in lockstep with the nation's war policy. Everything was geared to the first test of the new weapon being developed at Los Alamos: a vitally important test, results of which would directly affect the posture of the United States at the planned "Big Three" (United States, Russia, and Great Britain) conference to be held in the late summer. (It was at first expected that the outcome of that conference would determine the circumstances of nuclear weapon deployment against the Japanese.) It had been estimated that a sufficient number of high-explosive components could be produced at Los Alamos for one or two implosion weapons that were needed immediately. If more bombs were required later, it was

doubtful whether the S-Site at Los Alamos would be able to produce the explosive components. Groves, who had much experience with ordnance plants, feared the specter of a disastrous explosion at Los Alamos that might wipe out even the limited capability of producing the high-explosive components. In that eventuality there could be no nuclear weapons on hand or in reserve.

It is perhaps unfair to speculate that without the past experience of the China Lake Pilot Plant, Salt Wells could not have gotten off to such a prompt start so smoothly. But the experience certainly helped. This time, all the intricate elements were dovetailed into a perfect fit: the Bureau's requirements in terms of construction standards and safety; site suitability and location; and a clear understanding of what was required by CalTech planners and their chosen architects and engineers, the firm of Holmes and Narver. This understanding, in turn, was clearly transmitted to the construction contractor, Haddock Engineers.

Even the funding of the project had been firmly established from the beginning. The first funds from the Manhattan people were received within two weeks after Sage's sketchy plan was approved.

There were some problems, of course. A goodly number of these predictably stemmed from the fact that some of the manufacturing processes for which the plant was being built were not yet determined. For example, in February Los Alamos could not be sure whether the casting or pressing method was better for fabricating the high-explosive blocks. Up to a certain point, basic facility design could have accommodated either process. In fact, K. H. Robinson recalls that Detroit built a special die for pressing (to be used on CLPP's 18-inch press) against the possibility that pressing might be the ultimate process.⁶ However, meeting the deadline hinged precariously on a much-needed decision. By mid-April it was apparent that precious time was slipping away. Lauritsen confronted the powers at Los Alamos and bluntly insisted that a decision be made at once. It was, and construction was promptly geared for the melt and cast method.

Because the designers had to stay one jump ahead of the vigorous building contractors, who worked on a three-shift, no-holiday schedule, the design group under Willis Jaynes in Pasadena worked at a killing pace. Such were the working hours that a former member of the design group recalls walking out of his office and idly wondering why the sun was setting in the east; he had worked throughout the night without realizing it and was observing the dawn.⁷

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In direct charge of all equipment, specifications, and plantflow decisions. Sage had placed Paul A. Longwell, a brilliant young chemical engineer from CalTech who had performed the same function for the Eaton Canyon plant. As quickly as Longwell's group would set the specifications for a unit of processing equipment, the design group would consider the problems, complete the drawings, go back for approval, and then place the item out for fabrication.

Characteristically, the capable arm of the Bureau of Yards and Docks was present to add its strength. Lewis Moeller, described by a former Pilot Plant officer as "a very senior captain and a very brilliant man,"⁸ perceived early that miracles were going to be needed to meet the schedule. Accordingly, he assigned his best subordinates to the job. One of these, Lieutenant Lou Asbury, Civil Engineer Corps, worked tirelessly on the problems of planning and equipment.

Several items presented unique engineering problems. For example, the jacketed molds surrounded by water-cooling coils proved exceedingly difficult to fabricate and operate. Actually, the molds went through several series of designs, and actual production processing had begun before a satisfactory treatment finally evolved. Although not apparent in early designs, severe problems were also imposed by having to learn how to cast nonporous aluminum.

The melting kettles presented unique challenges. As each kettle contained enough high explosive to level the entire building, they were designed for remote operation and control. Accordingly, the mixing blades, kettle contours, cooling jackets, and tilting supports—all of stainless steel—had to be fabricated to a specific but new design. Initially, such elaborate kettles were impossible to find. As a temporary expedient, commercial candy kettles of 30- to 50-gallon capacity were modified for Salt Wells use. It is reported that these never presented any serious problems during their short service; however, their melting capability was too slow to handle the desired production. As safety considerations were paramount, a complete periscope-type optical system was devised and built that enabled the control-room operator to machine blocks of high explosive to close tolerances even though separated from his work by two heavy concrete walls. Since precise measurement of the product was critical, all buildings were designed to hold the temperature to a tolerance of plus or minus 2°F.

Another complex requirement for the new, untried production process was to determine that no fissures or cracks were present in the finished explosive blocks. Dr. Jacob ("Joe") Bujes, a

Hungarian-born scientist of CalTech, was brought in to develop special radiography techniques for inspection and to supervise this hazardous operation.

The design group's headaches were not limited to facility construction alone; they had to contend with problems of equipping the new plant. They were constantly asked to prepare bills of materials and to specify the precise day on which the items would be required. Miraculously, trucks would subsequently roll up to the Salt Wells security gate on the specified day to deliver the needed motors, valves, controllers, switches, and regulators. Lieutenant A. L. Pittinger later recalled that two of these trucks contained Cleaver-Brooks boilers needed for the plant's steam supply. Apparently Lieutenants Pittinger and Asbury had searched "all over the West Coast" for suitable boilers, finding nothing but used ones that Sage flatly refused to accept. Finally, some new boilers were spotted "sitting on the ground at another ordnance plant." Pittinger added, "We managed to spirit them away before anyone caught up with us"⁹ Thousands of items were unobtainable to other agencies. However, CalTech's careful and precise definition of their needs, plus the authoritative magic of the Manhattan Project priority, appeared to be a winning combination; as such, it made procurement history. Much later, these unbelievable shipments were explained by a Manhattan Project Army officer who stated that, in many cases, his representatives were waiting at production plants for the items to come off the lines. When finished, these items then received an Inyokern tag. That a shroud of secrecy cloaked the entire procurement operation makes it, in retrospect, even more remarkable.

The whole aspect of security for Salt Wells is somewhat unusual because the secrecy was preserved intact for so long. The entire principle of the security program was "compartmentalization of knowledge"; each person was entitled to know only a limited detailed part of the Salt Wells operation. All were specifically enjoined against speculating on the entire program, as the project required the utmost secrecy. Thus, even though many hundreds of workers, including construction men, designers, procurement and supply officers, clerks, engineers, and scientists had been motivated to extraordinary efforts to complete the plant, only a handful knew its purpose. Security approached unprecedented dimensions for one girl whose job required her to account for hundreds of component parts, the end use of which she never knew! A subsequent Commanding Officer recalled that "when visiting admirals came around, there was never an

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explanation given of the Salt Wells Pilot Plant other than 'That's our secret area.'"¹⁰

Side by side with security was the salient characteristic of safety. And while the former delighted the heart of General Groves, it appeared to him that there might be overconcern with safety. He was apprehensive that the meticulous attention to such refinements as reinforced-concrete structures, barricades, blast doors, electrical shielding, and sensitive deluge systems might be overdone and would cost him and his project time, which would delay the completion of Salt Wells.

History records that the deadline for plant completion was missed by 15 days. Pittinger made a final comment on the missed deadline: "When you consider how long it takes today to get a dog house built, it is nothing short of a miracle that Salt Wells was melting explosive [within] 115 days."¹¹

On July 25, 1945, the first high explosives were melted, mixed, and poured at Salt Wells. This was nine days after the successful test of the world's first nuclear weapon (code-named "Trinity") at a remote site near Alamogordo, New Mexico. It was an implosion



Salt Wells Pilot Plant under construction, July 1945.

weapon featuring the same kind of high-explosive components that would shortly be produced in quantity by the brand-new ordnance pilot plant. In brief, nine days after Trinity proved that the implosion principle would work, the plant at NOIS was beginning to manufacture the critical high-explosive components.

PROJECT CAMEL

One of the means by which work for the Manhattan Project was safeguarded at NOIS was the use of a security name: Project CAMEL. There is no official explanation of how Project CAMEL got its name. One version attributes it to the remark made by an unknown Los Alamos scientist on learning that CalTech was going to be involved in certain aspects of the nuclear weapons program: "You know what happens when a camel gets its nose under the flap of a tent!" However, the name itself has no importance. Bizarre and mysterious code names were common in World War II, especially those used to mask a highly classified activity.

The project name of CAMEL was used to describe all the technical work performed by CalTech for the Manhattan Project: detonator testing, the Salt Wells Pilot Plant processing and test work, the air drops of bomb shapes from Army B-29 bombers, and checking out equipment procedures to be used in the tactical delivery of the atom bomb.

The drop tests with the B-29s occurred in the spring and early summer months of 1945. These bombers were almost the first aircraft to use the barely completed Armitage Field, Manhattan funds having been provided to lengthen the runways by 1,000 feet for the B-29s. This part of CAMEL must have been quite mysterious to a lot of people who worked at the Station. After all, it was well known that the thrust of the work at NOIS was aimed at the development and test of aerial rockets. And although rocket launchers were being devised for a wide assortment of Navy and Army aircraft, large and small, there could surely be no plan to equip the enormous bombers with such installations. There was certainly no external evidence that such was the case. Despite the harmonious relationship that existed between the Navy and the boys in the olive-drab uniforms who maintained, serviced, and flew the B-29s, when it came to discussing their mission, they were exceedingly close-mouthed.

If it could have been divulged, the purpose of the B-29s would

have been clear, they were being used to conduct aeroballistic tests to determine the optimum aerodynamics of the atom bomb and to test the functioning of fuzes.

Actually, air-drop tests for the A-bomb project were extensive and were conducted at several locations throughout the country. Early tests, principally for the fuze development program, were held at the Naval Proving Ground, Dahlgren, Virginia. Subsequently, taller scope testing moved to Wendover Air Base, Utah (where the B-29 crews for the eventual Japanese mission were trained), and to Muroc, Salton Sea, and Inyokern.

If there was an unprecedented scientific challenge to translate nuclear theory into demonstrable fact, there was also a significant technical challenge in converting an untried nuclear device into an effective air-delivered weapon. This was the main task of Captain Parsons' Ordnance Division at Los Alamos. The problems were formidable, and they were experienced in both configurations being considered, Fat Man with a girth of 5 feet, and Little Boy that was more than 10 feet long. Although the bombs' dimensions were expressly selected for B-29 application, both configurations required modification of the actual bomb bays and the designing of lugs for securing the ungainly weapons.

Aerodynamically, the early bomb configurations were patently incapable of accurate flight. The centers of gravity were improperly located and the first dummy bombs tumbled erratically and dangerously. One naval officer who was deeply involved in the program commented in an interview, "This was a *cozz* bomb. It was built about like a streamlined brick, and to get [it] to fly reasonably well ballistically was quite a chore."¹² The bomb required hundreds of drop tests and experiments with different fins and weight distribution before these problems could be solved; tests that could be observed and recorded by sophisticated instrumentation cameras.

The Inyokern ranges were well instrumented for aerial rocket tests. Also at NOTS it would be possible to obtain the specialized help of the instrument shop staff of CalTech's Dr. Gerald Kron in devising and operating special-purpose instruments for the tests. These are probably the reasons that the NOTS site was selected for the CAMH project.

The need for a range where bombs could be recovered after penetrating into the ground may also have influenced the selection. In a conversation with the bomb recovery crews during the early days of testing at Wendover, Commander Hayward was told of recovery

problems that required digging to incredible depths in the soft sand of that area. Hayward is reputed to have said, "If you dropped the bombs on our NOIS rings, I guarantee you wouldn't have to dig more than six feet." Hayward apparently underestimated the incredible ground-penetration capability of the bomb when dropped from 25,000 feet. The first dummy bomb dropped at Inyokern penetrated the desert floor so deeply that it took days for a team of men with earth-removal equipment to reach it. When the bomb was finally recovered, Burroughs remarked that the hole it left would have accommodated "a ten-story building!"¹³

Whatever the circumstances that brought the air-drop tests for the A-bomb project to NOIS, it is logical to assume that most of the NOIS involvement resulted from decisions by Parsons. Throughout the development of the A-bomb, Parsons led the design effort on the gun type, Little Boy. When the critical aspect of air-drop testing came up, he predictably turned to the Navy for support. In addition to serving as the head of the Ordnance Division at Los Alamos and as one of Dr. Oppenheimer's deputies, Parsons was eventually put in charge of all work concerned with the final preparation and delivery of combat bombs. His remarkable background in ordnance made him skeptical of untried paper studies. This skepticism was largely influential in bringing about the extensive test program using actual bomb shapes at Wendover, Muroc, Salton Sea, and NOIS.

The selection of test sites was not random, and each location was picked for a special reason. Salton Sea, for example, is below sea level. In 1943 this was highly significant because the new B-29 bombers had difficulty in reaching and maintaining high altitudes due to the tendency of their engines to overheat. On the other hand, Wendover, Utah, although several thousand feet higher than Salton Sea, was an ideal air base for the secret formation and training of the bomber crews who would drop the bomb in combat. All were isolated sites.¹⁴

It was undoubtedly the Parsons penchant for advance testing that brought to NOIS early in 1945 a strange mass of materials and equipment with the official description of "One Kit, Bomb Assembly." The "Kit" was a creation of Parsons' deputy at Los Alamos, Dr. Norman Ramsey, who later described its genesis:

I had worked with the Air Force for a year in Washington and knew full well that, no matter what your priority, you couldn't get things out without a table of organization and a table of equipment. I think one of the cleverest bits of red tape I ever produced was inventing one item of equipment that was known as "One Kit, Bomb Assembly." You know, it

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sounded true, so it went through, and it approved as part of the table of equipment for the 509th group. Anything we needed from that point on was always put as part of the "Kit, Bomb Assembly." This included about half a dozen quonset huts and two of these 40 x 80 foot arch steel ribbed structures, and air conditioning equipment, all this in the "Kit, Bomb Assembly." Now it's true, we didn't get away with this just by clever device. The people were quite prepared, had been warned. The first time they objected at the Port of Embarkation. Parsons responded with sufficient vigor that from that point on they were willing to take anything we asked for.¹⁸

Ramsey also recalled that four of the kits essentially self-contained bomb assembly *facilities* were made. The one that was used to assemble the Hiroshima and Nagasaki bombs, together with a spare, was sent to Tinian, a small atoll in the Pacific; one was held (it is believed) at Wendover as a reserve, and the other was installed at Inyokern.

The two assembly buildings and a warehouse in the Inyokern kit were erected about a mile to the east of Armitage Field. In one of these buildings Enory Ellis and Burnham Davis assembled the first test bomb (without the nuclear core) that actually used high-explosive blocks.

For Ellis and Davis also the entire Navy CalTech complement at Inyokern the true meaning of their labors became starkly clear on August 6, 1945. On this date, the name "Hiroshima" became synonymous with the dawn of a new era in weapon technology.

Along with newspaper reports of the bombing, a telegram from the Undersecretary of War was relayed to "All the men and women employed on the CAMER Project":

TODAY THE WHOLE WORLD KNOWS THE SECRET WHICH YOU HAVE HELPED US KEEP FOR MANY MONTHS. I AM PLEASED TO BE ABLE TO ADD THAT THE WARLORDS OF JAPAN NOW KNOW ITS EFFECTS BETTER EVEN THAN WE OURSELVES. THE ATOMIC BOMB WHICH YOU HAVE HELPED TO DEVELOP WITH HIGH DEVOTION TO PATRIOTIC DUTY IS THE MOST DEVASTATING MILITARY WEAPON THAT ANY COUNTRY HAS EVER BEEN ABLE TO TURN AGAINST ITS ENEMY. NO ONE OF YOU HAS WORKED ON THE ENTIRE PROJECT OR KNOWN THE WHOLE STORY. EACH OF YOU HAS DONE HIS OWN JOB AND KEPT HIS OWN SECRET, AND SO TODAY I SPEAK FOR A GRATEFUL NATION WHEN I SAY CONGRATULATIONS AND THANK YOU ALL. I HOPE YOU WILL CONTINUE TO KEEP THE SECRETS YOU HAVE KEPT SO WELL. THE NEED FOR SECURITY AND FOR CONTINUED EFFORT IS JUST AS GREAT NOW AS IT EVER WAS. WE ARE PROUD OF EVERY ONE OF YOU.

ROBERT P. PATTERSON

Significantly the end of World War II did not, as in the World War I armistice of 1918, signal the demise of weapon research and

development. Rather, many military leaders in all the services took it as the starting gun for crystallizing plans and moving forward. Among those most influential in developing the Navy's postwar research and development programs would be Parsons, who, by his technical leadership in the Manhattan Project and in his key role in the final days of the war, had become the acknowledged expert of the Navy on ordnance research and development, particularly on nuclear matters. Despite a natural modesty, he fully recognized his was a unique position and responsibility. On September 2, 1945, Parsons, by then promoted to the rank of Commodore, wrote to Thompson:

Dear Tommy,

Surrender was signed today. This evening Tokyo Rose ended her broadcast with a quotation from Major George Fielding Elliot; and the program then swung into the Mikado! A few more days of this love feast and we'll be able to start home . . .

Soon after I get back I hope to get the situation in mind by looking over the various sites including NOIS and then I'll go to bat for the most logical peacetime setup for Navy weapon research and development. From here it seems that some high-powered intermediate and long range planning is in order soon.¹⁶

But at NOIS the time had already arrived, for the desert Station had entered a period in which problems to do with the transition from war to peace had already begun to appear.

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16. Parsons letter, cited in Ref. 3 above.

Peace and Transition

A heightened awareness that the Second World War was about to end began for NOTS on August 10, 1945. On that particular Friday, the Experimental Officer witnessed an emergency landing of a TBF. The log states: "Fire and crash crews were not alert. Commander Hayward said it was the sorriest showing he has ever seen!" [Emphasis in original.]

Maybe it was something sensed by all, and not alone by the lethargic fire and crash crew; possibly some radio news flash heard by someone, or an editorial comment in the fast-unfolding news story of Hiroshima and Nagasaki. It might even have been the same source of information that compelled the Duty Officer to write in the log at 0620: "The war appears to be over???" Four days later, on August 14, another Duty Officer made the cryptic entry in his log, "1600 (APPROX) WAR OVER VJ." Fifteen minutes later, he added, "SECURE FIELD 48 HOURS."

As the jubilant liberty parties went "over the side," bound for Los Angeles and then to their homes, undoubtedly those whose service was "for the duration only" had but one thought in mind. It was over! First celebrate victory in the time-honored Navy fashion; then look forward to a speedy return to civilian life. Others, however, must have had more sober thoughts. To them, it was time to pause and contemplate the future of NOTS as a significant page of the Station's history was being turned. The winds of change had already been blowing for many months; it was correctly sensed that they would soon acquire gale force.

A NEW COMMANDING OFFICER

In April 1945 when Burroughs' orders were issued to assume command of a brand-new escort carrier (U.S.S. *Cape Gloucester*), one with a particularly sensitive nose might have detected the nuance of a changing breeze. But neither Burroughs nor anyone at NOTS could have forecast the major squall that began to pick up force coincidentally with his departure. The exact time is recorded in the Duty Officer's log of August 18, 1945:

1055. Captain S. L. Burroughs, Captain J. B. Sykes, and Commander Richmond arrive Armitage Field. Captain Burroughs piped over the side.

1105. Captain Burroughs departs for San Diego in JRB #44661, accompanied by Lieutenant Commander Vossler.¹

The war had been over for only four days, yet at NOTS Inyokern, the subject of the new Commanding Officer must have rated as much discussion as the recent sudden capitulation of Japan. What kind of man? What background and war record? How would he affect the Station? The Navy people were well aware of the influence on their destinies that a ship's captain could exert. The civilians were equally aware that the military-civilian relationship at NOTS, although at the highest level of cordiality and cooperation during the war, had nevertheless shown exposed nerves from time to time. How would the "new Skipper" handle these in the future? It was only natural that perfunctory comparisons were being made between the new Commanding Officer, Captain (later Rear Admiral) James Bennett Sykes, and his predecessor, Sherman Everett Burroughs, Jr.

According to what was superficially known, the two men seemed to share much in common in terms of background and experience. Both were Easterners: Burroughs born and raised in New Hampshire; Sykes' early childhood had been spent on the Atlantic coast in Newport News, Virginia. Even in physical appearance, there was a certain similarity: each man bore the unmistakable erect carriage so characteristic of the Annapolis graduate and wore a clipped military mustache. There were many common elements in Navy background, too: ordnance postgraduate, naval aviator, and distinguished service with the Fleet and at the Bureau of Ordnance. The only apparent salient differences between Sykes and Burroughs appeared to be that Sykes was some eight years older and wore on his tunic, in addition to his gold naval aviator's wings, the prized dolphin emblem of a qualified submariner. But those who made the early, hasty comparisons would shortly learn that the individuals who wore essentially similar tunics, were, in fact, remarkably dissimilar.

PEACE AND TRANSITION



Captain James Bennett Sykes, the Static's first peacetime Commanding Officer.

Sykes, called "Jimmy" by those close to him, was a firm man. Even at an early age he demonstrated he could make and stand on his own decisions. As a young boy in the Navy town of Newport News and the son of a Navy chaplain, he first felt the strong call of the sea. While he was in high school, an ambition to enter the Naval Academy became firmly rooted. After two years of pre-med, he approached his congressman personally, and only after he had received his appointment did Sykes' parents become aware of his initiative.

Throughout his naval career, Jimmy Sykes prided himself on his ability to quickly weigh probabilities and take action accordingly. His personal viewpoint in an interview years later was, "After I have decided what I am going to do, I am all for it." This credo was dramatically illustrated when he was in command of the attack carrier, the U.S.S. *Bennington*. Two badly damaged aircraft were coming in for a landing: a fighter followed by a torpedo plane with a badly injured pilot at the controls, who, it was evident to all, had but a single chance to attempt a landing. The fighter landed and immediately caught fire. In a split second, the Captain made a decision: push the burning aircraft with the pilot still in the cockpit over the side. To Sykes the probabilities were instantly clear. The strongest of these was that the pilot of the fighter would escape from the jettisoned aircraft and float, and that three lives in the torpedo plane outweighed a single life in the eventuality that the fighter pilot might founder. As it happened, all four lives were saved.

Sykes proudly regarded his command of the *Bennington* as a high point of his naval career. In a later interview he said, "Out of 3,600 men, during the eleven months I was in command, no one was lost other than the pilots when they had gone off to combat from the ship."² He added that out of eleven carriers, they saw six hit and burned. It was the *Bennington's* aircraft that flew protective cover for the stricken *Franklin*.

Although Sykes was aware that his ordnance postgraduate training bestowed a certain amount of recognition and prestige upon him and made him a member of "Spike Blandy's Gun Club," he saw little personal benefit from the training. He later commented, "It did not serve my purpose; on the whole, it was a waste of time."³ He felt that there was too much emphasis on, for example, the design of a generator and that the most the students would get was only a superficial understanding of the design work. His viewpoint is remarkable in that it was in contrast to the praise generally received from officers who went through the program. Most saw the "Gun

Club" training as a valuable opportunity to broaden their experience in ordnance and science, while benefiting at sea from their understanding of weapons systems introduced into the Fleet.

When the new Skipper assumed command of NOTS, he did not regard himself as a stranger. On the contrary, he felt he had been instrumental in starting the Station in the first place. As the Aviation Assistant in the Planning and Progress Division in the Bureau of Ordnance, he had successfully handled several money requests from Burroughs in the early days. His reaction when he first reported to NOTS was, "I was surprised to find what a big place I had helped to get started."⁴

BEGINNING OF A CRUCIAL ERA

When the new Commanding Officer of NOTS assumed command, NOTS faced immense problems of transition from war to peace that characterized the period for military commands across the nation.

After the initial jubilation of victory, the morale of those remaining at the Station generally plunged. The war had ended, and the attrition of key military and civilian personnel was beginning to pinch. There was a sudden loss of motivation with the loss of the spirit of "let's pull together and win this war." Uncertainty filled the void; uncertainty as to the changing pattern of Navy research and development, and how talent in the technical fields could be fitted into the peacetime military organization.

From the beginning Sykes was confronted by a host of problems that took on new dimensions in the switch from war to peace: administration, housing, messing, transportation, security, and supply.

More than twenty years later Sykes expressed the feeling that his briefing by Burroughs prior to assuming command left a lot to be desired. Their discussions were brief and centered around the Salt Wells operation and the Manhattan Project. Sykes recalled "... a little trip out on the mesa in a jeep to talk about this because of the security problem of the time." Burroughs had "offhandedly" explained, "Well, you have some facilities in Pasadena; you have some at Morris Dam." These facilities were pointed out on a map, but Sykes had to find out for himself "what these places did." He said, "I took a trip to find out how far my authority extended; I never did find out."⁵

THE GRAND EXPERIMENT AT INYOKERN

The Sykes reaction may well have been a reflection of the uncertainties due to the transition from war to peace, and other changes such as the transfer of facilities and programs from the civilian scientific organization of OSRD to Navy management.

If Burroughs did not tell him, Sykes soon learned that commanding a new research and development facility was very different from sea duty. And Sykes soon learned that being in command of this remote desert Station also implied being the mayor of an entire city that comprised a bank, stores, beauty parlor, bowling alley, schools, churches, and residences—and several thousand civilians. Moreover, much of this “city” was still under construction, and so he also inherited a multimillion dollar construction contract. To compound matters, money was now tight, and such contracts were beginning to get the full focus of the bureaucratic review. Work on the new laboratory had ground to a halt some three months earlier, pending, among other things, a total renegotiation of the contract. Labor disputes were occasionally flaring up, and Station management—together with the Eleventh Naval District, the Department of the Interior, and various congressmen at the state and federal government levels—was heavily involved with land-acquisition wrangling. Perhaps it is not to be wondered at that Mrs. Sykes recalled many occasions when her husband came home and said he would “rather fight the Japs any day.”⁶

THE PASADENA COMPLICATION

Sykes had been critical about his predecessor's briefing, particularly with regard to “some facilities in Pasadena . . . some at Morris Dam.” Yet in view of the fluid and complex situation attendant to Inyokern's new acquisitions, it is doubtful whether any briefing could have conveyed a clear picture as to what was happening there during the immediate postwar months.

In the context of a larger picture, the problem seemed simple enough. OSRD was to transfer its major CalTech programs—rocket, underwater, and CAMEL—to the Bureau of Ordnance. Included in the transfer were related facilities and equipment, and those CalTech personnel who wished to continue working for the U.S. Government. All were slated for gradual absorption by the Bureau of Ordnance's Naval Ordnance Test Station with its headquarters at Inyokern.

Unfortunately, at the end of the war when these plans were to take effect, NOTS was not adequately staffed or equipped to handle

the entire transfer package; nor would it be for some considerable time. Interim measures and expedients were necessary, and from them stemmed a large bulk of the NOTS Pasadena problems. A case in point was Contract NOrd-9286, let on August 1, 1945, by the Bureau of Ordnance to the General Tire and Rubber Company (GT&R).

It was a substantial contract for its day, averaging more than \$207,000 per month.⁷ The Bureau hoped that GT&R, in providing materials and services, would ease the burden of running the show in Pasadena until the Navy could completely take over. At the time, a period of one year was thought to be sufficient. This particular foresight proved to be in error; the contract would run for three years.

In sum, the GT&R contract was more than an asset. It was a necessity. And while the company's contribution was remarkable in fulfilling the needs of the transition period, it generated formidable organizational complexities—principally, for the Commanding Officer, NOTS Inyokern.

For a start, GT&R dealt directly with its contract holder, the Bureau of Ordnance, through the Bureau's on-site representative, the Naval Ordnance Officer, whose organizational relationship with NOTS was defined as merely to "maintain a close liaison with the Commanding Officer."⁸ This meant that only a tenuous control, if any, could be exercised over a major operation that contractually furnished "experimental material and services...research and development activities for Underwater Ordnance."⁹

The GT&R contract impinged directly on the operations at Inyokern as it was to provide "experimental material and services...research and development activities required for Project CAMEL."¹⁰ In actual fact, the "services" at Inyokern were minimal. But at Pasadena they were considerable and far-ranging, including such items as administration, payroll, personnel, and facility building and maintenance. The company also took over the operation of more than 100 vehicles, including lift trucks and portable cranes. As a further indication of the contract's scope, GT&R also administered 487 active subcontracts in the metropolitan area of Los Angeles.¹¹

Compounding the organizational problem was the heterogeneous mix of the nearly 500 people who worked in the huge, 60,000-square-foot Foothill Plant operated by GT&R. It was a universal understanding that all these employees would ultimately acquire civil service status. But for a considerable period of time, "NOTS Foothill," as it was called, housed GT&R personnel, CalTech employees waiting to transfer to civil service, and those who had

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already made the transfer; in addition, there was a category of workers hired by the contractor (and on the payroll) with the understanding that their transfer to civil service was imminent.

This anomalous situation was recognized by the Bureau in October 1945, when Hussey cautioned:

Successful operation of the [Foothill] plant with both contract and Civil Service employees will require tact and cooperation between the administrative agencies involved--the Naval Ordnance Officer, the Commanding Officer, Naval Ordnance Test Station and representatives, and the contractor.¹²

Yet another command aspect of the NOTS Pasadena operation that caused Sykes some concern was described in a CalTech planning chart as the "Morris Dam Station." The Dam was one of the first of CalTech's activities to be transferred to the Navy (July 1945), and it had promptly been assigned an Officer-in-Charge by the Bureau of Ordnance. Evidence shows that Commander W. H. Keighley had firmly taken command. It also seems that Keighley was an outspoken, "no-nonsense" type of skipper who strongly espoused the responsibilities and prerogatives of command.

Keighley was predisposed to dealing with the Bureau of Ordnance directly on occasion, eschewing the established chain of command through NOTS. He might have been encouraged in this to a certain extent by those with whom he interfaced in the Bureau who put large store in the high-priority torpedo development and testing program at the Dam. Moreover, the Metropolitan Water District of Southern California leased the usage rights of Morris Dam directly to the Bureau of Ordnance rather than to the Naval Ordnance Test Station. This agreement for the use of Morris Dam was for a ten-year period with option for renewal for an additional ten years.

In a letter dated January 10, 1946, to the Bureau of Ordnance regarding the clarification of the status of Morris Dam, Sykes complained that he was not the direct addressee of requests for certain tests and cited a reference to the effect that "all personnel employed at Morris Dam and in the Pasadena Area are attached to either a division or department whose head is at Inyokern."¹³

The record shows that Sykes went to great pains to determine and clarify his command responsibilities in Pasadena. In so doing, he probably contributed toward an overall solution to the Pasadena problem, which, after all, resulted essentially from the transitional, fragmented character of the Pasadena operation. But as he initially regarded "NOTS Foothill," "Morris Dam Station," "NOTS Green Street," and a hodgepodge of equipment, people, and activities, he perceived mainly organizational disarray. It was understandably

difficult to see beyond this disarray what was the *purpose* of it all: the programs of CalTech imminently destined to become those of NOTS Inyokern—robust and dynamic program, whose essential health enabled them to continue and flourish throughout the difficult transition period.

The situation in Pasadena was probably at its worst when Sykes assumed command. But it would improve with each passing day. Irrevocably, the OSRD-Navy plans would be realized as all the scattered program elements were unified into a well-integrated, efficient NOTS operation. Additionally, personnel relations with the parent Station at Inyokern became better established in Pasadena, largely through the efforts of William Henry Saylor, former CalTech engineer, who was recommended by L. T. E. Thompson to be Technical Coordinator* (as well as Head, Underwater Ordnance Section).

One small aspect of the Pasadena problem was what to call the new, burgeoning operation. At first it was termed variously, "Pasadena Area," "Pasadena Activities," or more truly, "NOTS Pasadena." But sometime in 1946 it required a special name—"The Pasadena Annex." Special, first, in that it was an unofficial name that became official through usage; and second, because it eventually gave rise to much controversy.

"LIKE A BATTLESHIP . . ."

While history acknowledges a host of difficult problems at NOTS during the postwar period, at the same time it reveals a certain inharmonious relationship between the military and civilians as being potentially the most threatening to the future of NOTS.

As Dr. Emory Ellis recalled, there were relatively few differences at the working level between Navy personnel and civilians. It was his feeling that all people were commonly affected by red tape and the inflexible operation of Public Works, Supply, and Transportation.¹⁵ It was plainly red tape that provided the catalyst for bringing two different deeply underlying philosophies to a boiling point. The chief

* Saylor received his B.S. degree in civil and mechanical engineering from CalTech at the age of 23. He was the Head of the Dam and War Design Section in the U.S. Engineers Department, California, from 1938 to 1942. In 1943 he became Assistant to the Section Supervisor at CalTech until 1945. He then became Head of Underwater Ordnance Division, NOTS Pasadena, until 1947 when he was transferred to the job of Assistant Head of the Experimental Operations Department.¹⁴

protagonist for one philosophy was Dr. Wallace R. Brode, a scientist with extremely strong views on how science should be applied to military problems. And for the other there was Captain Sykes.

Brode, Head of the Science Department, arrived at NOTS one day before Sykes assumed command. Thus, he was present at the Change of Command ceremony. What he subsequently witnessed completely reaffirmed his deepest concerns about being a part of a military operation:

The new Commanding Officer on his first day had an inspection and lined up all his, shall we say, limited number of troops, whatever you call them out there, seamen, on the parade grounds for a formal transfer of Command. And he got all the scientists out too and lined them in a row. And he made a speech to the scientists. It was a short speech, and it was to the effect that commanding a research laboratory was no different from commanding a battleship. He proceeded then to issue a group of orders. Like a battleship we were in the middle of an isolated area in the desert and we had to have our proper supply. He was going to have none of this trucking off to Pasadena every day to get a new piece of film or a radio tube or something that burned out. We were to determine what we needed for six months and order it, and there wasn't going to be any of this quick ordering of materials. We had to figure what we needed for research for six months in advance and order it just as a battleship has to be stocked and ready to go to sea for six months at a time.

And it is that sort of philosophy which grinds the scientists to a halt very quickly. It isn't the same as running a battleship.¹⁶

Brode's dismay at the Sykes pronouncement that he was going to run NOTS "like a battleship" was shared by many of those who assembled on that showery Friday morning. The former Commanding Officer had never displayed that brand of authoritarianism. Navy personnel intuitively braced for the impending rigors of "old-time," "tight-ship" command. Scientists like Brode saw ahead the danger of a restrictive environment for their future research work. Such an environment would offset what few blandishments the desert ship offered. Thus, to a few at least, the concept of a permanent Navy research and development center seemed to be suddenly imperiled!

Early in the Sykes administration, a new rumor began to circulate. Even after thirty years the rumor persists. Sykes was operating under a set of "secret" instructions to "lick the place into shape." There is no substantiation of this rumor. In a later interview, Sykes said that he had not been given any special instructions. He declared that the only guidelines he had were, "You take command." He added, "So I took command."¹⁷

More mundane than the secret instructions theory, perhaps, are Sykes' own words describing his earlier operating philosophy:

They said that civilians should run the Station. My thought was, "No. I am here to provide everything you need and tell you what we want, and

all you need to do, is *do* it. I had the old-timey idea of a Navy station... a ship transferred to the beach where the Captain runs everything." 18

The determination of Sykes to "run everything" quickly brought him face-to-face with several strong-minded men at NOTS. The first of these was the Experimental Officer, Commander "Chick" Hayward.

As is generally the case, it was a relatively trivial issue that triggered nearly two years of continuing bad feeling between the two officers. As Hayward recalled, the first of many confrontations took place almost as soon as Sykes assumed command. Apparently the passenger manifest for one of Hayward's flights included the name of a female civilian (an employee of CalTech) who had regularly been making trips between Inyokern and Pasadena. Sykes contended that such use of Navy aircraft was illegal. Shortly thereafter, he similarly forbade the use of Navy buses to transport workers to the China Lake Pilot Plant.

Hayward recounted, "I said 'Aye, Aye, Sir,' and made the necessary phone calls to BuOrd to let them know that the Pilot Plant had shut down and the reason why." 19

From the beginning of their difficult relationship, Sykes seems to have considered Hayward as being "on the side of the scientists." As he put it, "He was more knowledgeable on technical things than I was but he was not concerned with orderliness or with regulations." 20 In the same interview, Sykes commented, "Our differences were constant but I have a high regard for him. Usually, he would tell me something after he had done it."

As contrasted with his relationships with Brode and Hayward, the new Commanding Officer of NOTS had a harmonious relationship at the start with one of the Station's most strong-minded men, Bruce Sage. Loss of the pilot plants, Sykes accepted the separate, autonomous status of the pilot plants as being efficient and orderly, and not requiring his personal intervention. Moreover, in many respects, the plants were "tenant" facilities the China Lake Pilot Plant answering to the Bureau of Ordnance, and the Salt Wells Pilot Plant to the Manhattan Project.

However, this relatively harmonious relationship was destined to be short-lived. In early 1946, a new Officer in Charge of Construction would arrive in the person of Captain Howard L. Mathews. As one fellow officer later put it, "Mathews was gasoline on the fire." 21 Mathews proved to be more than usually strong-minded regarding his construction prerogatives "on the hill" in Sage's domain. Consequently, a bitter feud developed between Sage and Mathews, one that eventually totally embroiled Sykes.

THE GRAND EXPERIMENTAL INNOVATORS



Captain John Tucker Hayward, NOIS Experimental Officer, 1944 to 1947

One more name must be given prominence in the story of the NOTS postwar personal relationships and the men that gave them character: Commander (later Captain) Alcorn G. Beckmann.

Often a new Commanding Officer uses influence to bring a personally selected Executive Officer on board. Sykes had not done this, preferring instead to continue with the existing "Number One," John Richmond. Richmond, whose principal personal assets were ability and tact, was highly regarded by everyone, military and civilian alike. Thus, he was able to apply oil to troubled waters at the onset of what was patently a brewing storm. But Richmond was overdue for retirement from active duty, and this occurred at the end of June 1946.

Sykes selected Beckmann to be his Executive Officer on the basis of a former Navy relationship: the latter had been First Lieutenant and Damage Control Officer aboard the U.S.S. *Bennington*. There was a mutual admiration. Beckmann regarded his former Commanding Officer as "a smart skipper . . . and a good handler of men."²² He was particularly impressed by the way Sykes had commanded the *Bennington* and was inordinately proud of the carrier's distinguished combat record. Similarly, on the basis of previous experience, Sykes saw in Beckmann a man he thought he needed: "an old-style Navy man whom he could depend upon to run a tight ship . . . a hard-boiled ship administrator."²³ Beckmann was all of these, and shared with his Captain an abiding concern for regulations, and the necessity of doing things "by the book."

The Inyokern assignment was not a popular one to Beckmann. He was told by the Detail Officer that he had been requested by name, a request endorsed by the Chief of the Bureau of Ordnance, for duty at "a secret naval base in the desert." Beckmann replied, "I don't have any idea what's going on there, and I don't want to know." He amplified this by affirming, "I'm a bachelor and I've spent the whole war at sea, and I'm due for shore duty; and I want some place where there's a little wine, women, and dancing, with singing thrown in."

He got in touch with Sykes immediately and was told that his orders were already being cut. Sykes added, "Get your hands on a copy of NCPI (Navy Civilian Personnel Instructions) and start burning the midnight oil and boning up on it, because you're going to be mayor of a city with three fire departments, elementary and high school, etc."²⁴

But it would take more than the NCPI and the "midnight oil" to engender a keen understanding of the curious and unique circumstances at NOTS.

In reviewing personal relationships in the tensivity of the postwar readjustments, it is important to recognize that the only clearly defined schism was between authoritarianism and scientific freedom. In such a split Beckmann and Brode represented the outside extremes. However, it was not a simple split with all the military on one side of the issue and all the civilians on the other; Hayward, for example, as a naval officer was clearly on the side of broad scientific freedom, and Sage as a civilian scientist was an authoritarian.

Sykes, at the storm center of the gale, later recalled how his new Executive Officer was "immediately at loggerheads with the scientists," but he was quick to point out, "I backed him up."²⁵

In a historical narrative of the Station, written in October 1946 Sykes appraised the caliber of his command both for "Service" and "Civilian" personnel. About the former he wrote:

In an effort to maintain the required number of men on the Station, a large number of "Short timers" with from one day to two months to do were ordered to the Station. These men were generally disgruntled, troublesome, and of very little value to the Station. The actions of service personnel during demobilization served to greatly lower the respect of civilians toward service men both socially and professionally.

Since July, the "on board" complement had increased to 808 on 1 October 1946. The increase had been largely in CPO and non-rated groups, including many ex-prisoners of war.

The average quality of personnel is well below pre-war standards. This is due primarily to lack of experience in the petty officer ratings. Living in close proximity to civilians, much more highly paid for similar work, gives the men a dissatisfied outlook. The servicemen are frequently called on for work outside of working hours to take care of emergencies instead of using Civil Service Personnel because of limitations on overtime work.²⁶

Sykes' evaluation of the NOTS civilian employees was similarly low.

There is a tendency for some employees to perform work in a perfunctory manner without producing reasonably expected results for a day's work. Supervision in general is poor, especially in the subordinate brackets. Unless the individual responsible, on a high level, actively takes charge of an operation, the work will lag. The process of obtaining and training a satisfactory supervisory group is proceeding slowly.²⁷

But Sykes' evaluation of personnel was measurably higher than that of his Executive Officer, who stated years later that only 30% of the civilians were dedicated and trained people. The remaining 70% were a "collection of no-good drifters or people running away from something." But it might be said his evaluation, whether extreme or not, was evenhanded, for he stated, "We had just as many

good-for-nothing klunkers in the military as we had in the technical staff."²⁸

The overall quality of both the military and civilian staff in the postwar transition period is debatable. Certainly it did not compare with the combined CalTech-NOTS rocket team of the war. But whatever the status, negative attitude directed at the whole team did not help make the Station a more desirable place for those who were trained and dedicated, whether the number was 70 or 30%.

At first glance, many of the postwar problems appear to be merely a list of petty grievances and complaints, which individually seem to be absurdly trivial in some cases, ludicrous. But to the people concerned at the time, the situation was without humor. Rather, the incidents collectively acquired an abrasive quality that tended, as Brode put it, to "grind the scientists to a halt."²⁹ If the situation had not been corrected it could have done irreparable damage to the Station by making it more difficult to recruit a higher caliber staff. At the heart of the problem was the fact that the Navy could not, to paraphrase a statement attributed to Dr. Albert Michelson, expect to keep first-rate physicists (or engineers, or administrators, or technicians) if it did not treat them as first-rate physicists.³⁰

Many of the individual complaints that added to the low morale stemmed from the inability and reluctance of civilians to adapt their lives to Navy regulations, and when an appeal was made at the command level, the judgment was generally made according to the book.

Unfortunately, Navy regulations often proved to be entirely inappropriate to guide the activities of a remote desert community populated largely by civilians. For example, Navy vehicles, specifically designated for the use of authorized personnel, provided nearly all transportation at NOTS. This was subject to different interpretations. A former employee recalled a typical incident:

It was all right for officers or enlisted personnel to have official cars to go to the PX or anyplace else, but not for civilians. And mind you we were on an isolated Base. We often had new employees come on the Base. In one case while the man was being briefed in or going through security clearances, the wife and small baby were sitting in the outer office. And the housing clerk was very sympathetic and said, "Can't I take you over to the PX and get some milk for the baby and take you on to your new house so you can get some rest?" It's a little drive to get there from anywhere. This was done just once. The girl drove the only car they had; of course it was a Navy car. They went over to the PX, and she got clobbered by the Navy for using a Navy car for civilian purposes. It's that unsympathetic, almost cruel administration that often moved people off the Base.³¹

Similar experiences have been reported throughout a wide spectrum of life at NOTS. Many complaints concerned Public Works:

... They're doing something good for your neighbor in the other half of the duplex, who is a Navy person, but you can't get them to repair a broken pipe on your side of the house... If there was an extra freezer it would go into one half of the duplex that was occupied by a Navy Chief and the civilian side wouldn't get a look at it. You'd get a piece of furniture... [only] after all the Navy people were satisfied.³²

Even after a bending of the rules permitted civilians to use the "quasi-official activities" (commissary, ship's service, etc.), it was required that two separate lines be formed: one for the officer's wife, another for the scientist's wife.³³

As time progressed, the volume of complaints burgeoned, and, in retrospect, a certain sympathy seems appropriate to the NOTS Commanding Officer and his equally harassed Executive Officer who were attempting to solve the problem by the book.

After the first rumblings of discontent, Captain Sykes announced an open-door policy: a fair hearing to anyone who had a problem. In time, he found himself overwhelmed by a barrage of problems—technical, administrative, and social. The open-door policy was in time terminated, perhaps as the result of the incident when an irate housewife deposited on his desk a spoiled chicken she had just purchased from the commissary.³⁴

Solution of the minor problems skirted around the principal issue from which they stemmed: the military-civilian relationship at the highest echelon of the Station, and how it affected the mission of NOTS. The philosophy of running a research and development organization "just like a battleship" implied ultimate disaster to many. The very conduct of the new programs appeared to be in jeopardy. The ablest and most qualified of the Station's top scientists and engineers were threatening to leave, and the recruitment program for new talent was suffering severe setbacks.³⁵ The basic question was repeatedly asked, "For what purpose is NOTS being run—research and development, or test services in the tradition of the old naval proving grounds?" If the essential spirit of the Knox establishing order was to be preserved, who could best direct the technical activities of NOTS—the military officers or the civilian scientists? And was there an effective compromise (such as envisioned by Thompson) wherein a large measure of independence could allow the civilian staff to work comfortably within the overall framework of the Navy?

As previously stated, conflicts among the strong-minded leaders of early Inyokern cannot be simply characterized as military versus civilian. Nothing illustrates this more clearly than the deep-seated

controversy between Captain Sykes and Commander Hayward. Hayward, who was essentially in charge of the technical programs, watched with concern the lowering of morale on the Station and the subsequent diminishing quality of the technical effort. He was aware that valuable people were leaving and that it was difficult to replace them. As he saw it, this pervasive erosion was Station-wide, affecting both military and civilian personnel, and presaged the ultimate loss of the original dream of a permanent research and development center for ordnance. To Hayward's way of thinking, such a loss to the Navy and the nation was unconscionable.³⁶

Yet, despite the many manifestations of troubled times, there was hope. For nearly two years of wartime operation, NOTS and CalTech had conclusively demonstrated that good military-scientific relations were possible and highly productive. In the immediate postwar period, the CalTech heritage of independent thinking was still strong at NOTS; moreover, although Burroughs had left, many of the original Navy team members who had worked in the enlightened wartime environment were still on board (Hayward, Richmond, Vossler, and Pittinger, to name a few). Here, at Inyokern, there was still an opportunity to extend a tradition of harmonious military-civilian relationship into the Navy's postwar research and development effort.

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Problems of the Postwar Watch

The difficult period of peacetime adjustment was not exclusive to NOTS alone. OSRD had not retreated from its firm determination to go out of business when hostilities ended. Consequently, despite months of advance notice, the armed services were generally ill-prepared to absorb their part of the massive scientific program built up under OSRD.

The severest problem was a lack of qualified, competent scientific personnel—compounded at NOTS by the aspect of living conditions in a remote desert environment. But there was another major impediment to successful recruiting of top-flight people: a distaste for the restrictions implied by the traditional military framework. Efforts to discover a new formula for a productive military-civilian relationship constantly stimulated the minds of the leaders at Inyokern during the immediate postwar years.

SEARCH FOR A DIRECTOR

For his first four months as NOTS Commanding Officer, Sykes did not have a full time Director of Research since Thompson, who was acting in that position, was dividing his time between Inyokern and Indianapolis. Thompson was still trying to influence Hussey in favor of nominating Lawrence Hafstad for the permanent position of Director of Research.

In a "Dear George" letter to Admiral Hussey on October 24, 1945, Thompson injected a note of quiet desperation regarding the availability of the new Director:

...I understand Hafstad has been willing to come if the Bureau would say the word, and I believe still is.

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It is now not so much a question whether Hafstad can do more effective work this year or next in Washington on a specific project. The present question is a bigger one—whether the Bureau's investment in what can be an outstanding research and development center at NOTS is to get off to a start which will insure a high level of success, or to a mediocre start from which it may never recover. . . .¹

Hussey's "Dear Tommy" letter received in reply did not lessen Thompson's concern:

While I concur with you fully, that top-flight research men are necessary for the Naval Ordnance Test Station, it is equally as true for the Applied Physics Laboratory of Johns Hopkins University. Hafstad is Tuve's right hand man, and with our Bumblebee research program in its present status I am afraid it would not be advisable or in the Bureau's best interests for Hafstad to transfer to the Naval Ordnance Test Station at the present time.²

Hussey's reasoning was sound. The Bumblebee Project was vitally important to the Navy and the Bureau of Ordnance, encompassing as it did, the entire ship antiaircraft guided missile research and development effort for which the Applied Physics Laboratory of Johns Hopkins University acted as the Bureau's government-owned, contractor-operated laboratory.

This effort was a brightly burning segment of the OSRD torch (formerly T-Division) that had been passed to the Bureau of Ordnance. The developmental jet-propelled, beam-riding antiaircraft weapons were considered to be essential in defending ships against air attacks. The harsh lessons of World War II had been hammered home in the form of the devastating Japanese kamikazi attacks. Not only were aircraft and their weapons going to improve, but the kamikazis had given a foretaste of the problems that would be faced when antiship guided missiles became more sophisticated.

Despite Thompson's strong recommendation to the Bureau of Ordnance, it would be erroneous to conclude that Hafstad was the sole qualified candidate for the Director of Research post at NOTS.

As a result of the war, there were more scientists with ordnance experience than ever before, but the number of top flight scientists who would consider government employment for the military services was small. It is perhaps appropriate to examine the basic reason: salary.

George Hussey appreciated this and eventually would be a key figure in helping to solve the problem.* But at the time a Director was being sought for NOTS, all Hussey could do was deplore the fact

* Hussey later worked with the Chiefs of the Bureaus of Ships and Aeronautics in getting the Chairman of the House Committee on Post Office and Labor to introduce Public Law 313. This was signed by the President on August 1, 1947. Under its terms, 30 scientific and technical positions, including that of the chief scientist at NOTS, would be established above the top civil service grade (then \$16,000 per annum).³ By its action Congress would finally remove one of the oldest blocks to a viable research program at NOTS and other government laboratories.

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that the top senior civil service salary was around \$10,000 per annum, a remuneration not sufficient in itself to attract the desired caliber of scientist with commensurate management experience.

Compounding the problem was a condition described by Irvin Stewart (OSRD's historian) as the "demobilization bandwagon"—a condition that affected most of the nation's leading scientists. Stewart summarized it as follows:

OSRD was created to do an important but temporary job. The organization was built on a temporary basis, drawing upon the best available men for relatively short periods of time without disturbing their regular academic or industrial connections in most cases. This was possible largely because of the pressure of impending and actual war which made men available whose services could not have been obtained on any comparable scale in normal times. The leaders of OSRD were always keenly conscious of this fact, which, however, completely escaped many people on the outside who, seeing the success of OSRD, called for its retention into peacetime. There was never any chance that this could be done. Once the pressure of war lifted, the key men upon whom its success depended responded to the more urgent calls of their regular activities and not all the king's horses nor all the king's men could hold the group together.¹

Thompson's wartime association with NOTS as a consultant and organization specialist had endowed him with an extraordinary insight as to the unique circumstances inherent to the desert Station. Now, with the replacement of the easy-going Burroughs by a less flexible Commanding Officer, Thompson was acutely aware that another dimension had been added to Inyokern's already complex management picture. Very special qualifications would be required of the NOTS Director of Research—beyond prestigious scientific stature and normal management ability. In Thompson's view, Hafstad was still the best candidate. But when he realized that Hafstad could not be spared for the NOTS position, this appears to have turned the scales in favor of taking the job himself; and by so doing, acceding to the long-standing combined pressures from the Bureau of Ordnance and "Ev" Burroughs.

Thompson's assumption of his new post was in the nature of a gradual phase-in over several weeks, beginning in October 1945. On December 4, 1945, his name and permanent title were printed on the Station's new organizational chart. NOTS now had a full-time Director of Research.

THE LABORATORY: HOPE RENEWED

"Construction Work Is Started on Five Million Dollar Laboratory." So read the headline in the Station newspaper, the

N.O.T.S. Rocketeer; the date was January 28, 1946. The lead article read in part, "Construction of the new laboratory at NOTS is now officially under way with the awarding of a \$5,060,000 contract to Johnson, Drake, and Piper of Milwaukee. . . . Actual construction will be in full swing by the middle of March."⁵

There were many whose hearts were gladdened by the news. For nine months summer, fall, and winter of 1945 construction of the laboratory had stood frozen at a 10% completion state, which dismayed many who viewed daily the formation and rusty tangle of steel rods. Others were still viewing the implication of the meager structure as a strong hope for a fresh start and a new laboratory in Pasadena.

When the decision to go ahead with the permanent laboratory was made in January 1946, a *de facto* research and development activity was already in existence at NOTS. In addition to the temporary electronics laboratory, there were many other laboratory functions in Quonset huts and temporary facilities pending completion of the main building. These included research in theoretical and nuclear physics, organic and inorganic chemistry, metallurgy, ceramics, ordnance, aeronautics, and meteorology. A report on the Station by Captain Sykes to the Bureau of Ordnance on December 8, 1945, makes reference to the fact that "temporary laboratory space in use at NOTS is about 40,000 square feet."⁶ In a report to the Board to Survey the Continental Naval Shore Establishments, Hussey wrote on May 3, 1946:

The new laboratory currently under construction at Inyokern is an applied research and development type laboratory concerned with studying and analyzing the fundamental scientific principles . . . with their engineering applications. Approximately 85% of the scientific and operating personnel associated with the laboratory are currently working at Inyokern in temporary quarters.⁷

By this time construction was in full swing. The contractor's work force of nearly four hundred had started with an energy that seemed to promise that all the months of inactivity would be offset by an extra effort. In another letter to the Assistant Secretary of the Navy on April 24, Hussey had commented:

At the present time construction of the laboratory is approximately 32% complete. About 95% of the materials required for the remainder of the construction are either on hand at the station, in a shipment status, or have been ordered. . . .⁸

The purpose of Hussey's letter was to obtain priorities for the remaining 5% of necessary materials; as Hussey put it, "without which

construction of the laboratory will be delayed." Clearly, everybody from the Chief of the Bureau of Ordnance down was anxious to get the job finished.

The urgency to occupy and use the new facility was widely felt at Inyokern and seemed to grow as did the walls of the new laboratory.

As they watched the new six-wing building take shape, the employees at NOTS periodically exercised a traditional "sidewalk superintendent" role. In this capacity they observed with interest all of the special features that were being built into the laboratory; for example, earthquake resistance, in that the wings, shop building, and main corridor were isolated from each other and connected by accordion copper flashing; also, there were extra reinforcements in the concrete structure, carried in the corners and junctions between outside walls, floors, and roof.

An additional feature of interest was the use of room partitions that were of a removable sheet steel type, built up in panels. These panels could be easily shifted to alter the size and shape of rooms to meet changes in activity and organization. Moreover, the two-layer sheet steel panels, separated by 3 inches of dead-air space, were coated with sound-deadening material for good acoustic and thermal insulation.

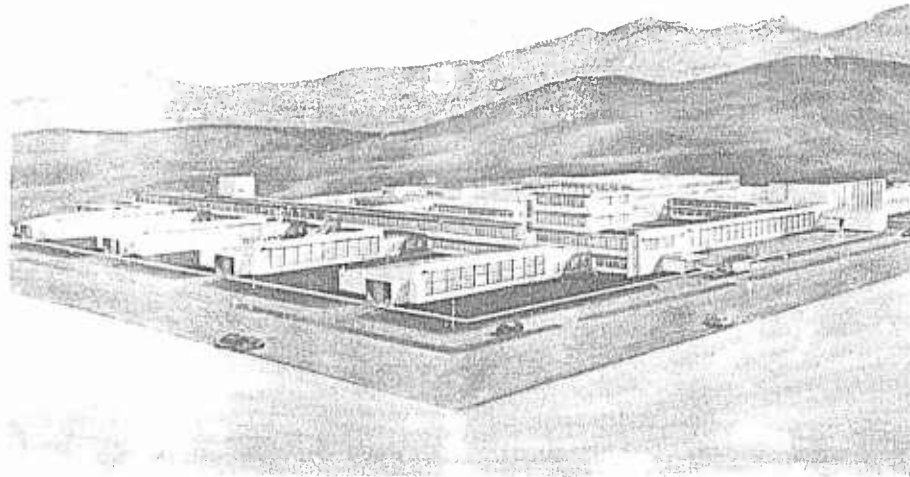
Particularly impressive was the air-conditioning system a combination of 14,000-ton Freon mechanical refrigeration and evaporative cooling systems that recirculated nearly 1,500,000 cubic feet of air per minute.

These and a host of other remarkable features that characterized the new NOTS laboratory impressed the observers at Inyokern and were brought to the attention of the building construction industry through an article in a trade journal.⁹ However, the Bureau of Ordnance in Washington beat no big drum publicly for their new research facility in the desert. On the contrary, it maintained a matter-of-fact attitude throughout the twenty-seven months it took to complete the laboratory. This attitude is typified in Hussey's letter to the Assistant Secretary of the Navy, previously cited:

The research, development, and test projects which have been assigned to the Naval Ordnance Test Station, Inyokern are part of the Navy's approved program for post war research and development. The facilities which are already constructed or are under construction at the present time are the minimum [authorized] required to carry out this program.¹⁰

But, despite this outward conservative attitude, the Bureau's determination to have a first-class research laboratory at Inyokern

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A 1946 drawing of Michelson Laboratory, July 1947.

not diminished. This was evidenced not only by the decision to go ahead with the facility construction program, but by an effort to acquire the requisite equipment.

DUNCAN BUYS EQUIPMENT

The procurement of equipment for the laboratory had little relationship to the construction progress. It had started before the foundations were poured and continued even though there was no room left to house the prodigious amount of equipment that had been amassed.

From onset back in 1941, James Duncan shouldered most of the responsibility. In a later interview he recalled his initiation into this responsibility as "NOTS Laboratory Officer":

I would go [to BuOrd] and make up lists of equipment and what we wanted. The thing that always amused me very much was when Captain Byrnes told me to go ahead and start buying equipment. I would say, "How do I go about this?" And he said, "Well, you just take this piece of paper and show it to people around here in the department where you want something and this is your account," and he wrote Yards

and Docks number so and so one and a half million dollars. He said, "When you've spent that, see my secretary and she'll give you some more." And so we started to buy equipment.¹¹

The assurance of such a largess of funds was a good beginning, and Duncan plunged into his task with great energy. Before he was through, that first \$1,500,000 would be spent almost three times over. Ironically, the ready supply of funds did not automatically solve all of Duncan's purchasing problems. Some of the needed equipment simply was not available at any price. The industrial firms that manufactured it were producing to capacity on the basis of long-standing priorities. It took the application of considerable pressure from the Bureau of Ordnance and of Yards and Docks to get the needs of the permanent postwar laboratory at Inyokern put high on the list.

Additionally, Duncan and others involved with procuring the equipment had the problem of adjusting their thinking in terms of quantity. Duncan's narrative illustrates this:

... We were setting up an electronics laboratory in a Quonset hut on the base without waiting for any of the permanent buildings and I got ahold of a young fellow named Luke Biberman. I gave him the assignment of buying electronics equipment to get started with, and I remember one thing I told him was that I wanted a number of oscillographs. It was almost inconceivable to Luke that anybody would buy more than one oscillograph. I sent him down to Dahlgren and let him see three oscillographs set up on one experiment so then he was willing to buy a half a dozen. And I told him to buy \$10,000 worth of small parts and this he did. This was the start of the electronic stock, long before we had the lab.¹²

But by comparison with the problems that were yet to surface the initial procurement of equipment appeared to be relatively blessed by easy success.

The harbinger of the greater problems appeared in early 1945 when it seemed that the war was being brought to a successful conclusion. Concurrently, the flow of money was reduced to a trickle as a wartime budget was pinched down for a peacetime one.

As an expedient, the Bureau of Ordnance conceived a plan whereby surplus equipment could be obtained from factories and plants that were closing as war production wound down. Basically, it was a good idea. Unfortunately, the gulf between idea and implementation in this case proved to be wide. For many, including the NOTS Laboratory Officer, procuring surplus equipment represented an ordeal in patience and tenacity. Duncan has set us a trip report that covers ten busy days in May 1946. It describes his activities concerning the surplus plant equipment from the Basic

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Courtesy Mrs. James Duncan

Captain James A. Duncan, NOIS Laboratory Officer, 1944 to 1947.

Magnesium Project, Henderson, Nevada, and other miscellaneous surplus equipment. An excerpt from the report illustrates how Duncan navigated through the labyrinth of bureaucracy:

May 1 I reported to BuOrd at 9:30 a.m. and immediately proceeded to contact R.F.C. [Reconstruction Financial Corporation] to release Basic Magnesium plant to NOIS. I phoned Mr. Frank Ronan, Chief of Contract Termination Section R.F.C. Mr. Ronan was out and I spoke to his assistant, Mr. Haines. I made an appointment to see him and went to the R.F.C. Bldg. After discussing the matter with Mr. Haines, I was referred to Mr. Callahan, contract attorney for the Basic Contract. I spoke to Mr. Callahan and learned that the plant was not declared surplus as yet but that immediate action would be started to get the necessary paperwork through. I then went to see Mr. Frank Davis in the annex of R.F.C. and he promised to expedite the declarations and suggested I see Mr. Carton at R.F.C. I made an appointment with Mr. Carton for the following day. R.F.C. notified me that after permission was given on an SF-5 declaration which is a declaration to declare the entire plant and property surplus, a SF-1 would have to be processed to release individual items from the plant. Then these declarations would be forwarded to War Assets who is the resale agency. I contacted General Gregory, Chief of the War Assets and was recommended to Mr. Gumble who was handling the Basic project. I tried to contact Mr. Gumble but he was at a meeting and was not available.¹⁴

This was only the first day of the trip for the indomitable Duncan. The next two days in Washington continued with more of the same. Help was sought from the Bureau of Ordnance to clear away the roadblocks; in particular, the Assistant Chief for Research Captain (later Rear Admiral) Kenneth H. Noble.* But both Noble and Duncan found the administrative complexity of the War Assets Agency to be beyond their efforts to untangle. All Duncan could do was to leave lists of NOIS requirements with the Agency. Despite Duncan's persistence, comparatively little equipment was obtained from surplus.

In all, over \$4,000,000 was spent for equipment that would be used in "the finest laboratory of its kind in the world." As Duncan put it, "We had all kinds of things like x-ray machines, testing machines, spectrographs . . . oscillographs. We had everything you need to get a pretty good-size laboratory going."¹⁵

And although the products of his arduous procurement efforts were still crated and stored in California warehouses, Duncan's optimism was markedly uplifted in early 1946 when it seemed that a final and permanent home for the scientific equipment and machine tools might soon be realized.

* During the war, the title of the head of the Bureau of Ordnance's Research and Development Division was Director. In January 1946 this title was changed to "Assistant Chief for Research."¹⁴

But building and equipping a laboratory was one thing; staffing it was another. Even as the completion work pressed forward, the NOTS-Bureau of Ordnance leaders were encountering a chronic recruiting problem. Recognizing the causes of the problem was easy; solving it was rather more complex.

"WE NEVER HAD ENOUGH HOUSES"

Personnel turnover in the postwar years was at a crippling rate with over 2,000 terminations reported in 1947, when the personnel ceiling was only 3,650.¹⁶

Many were the reasons for the high turnover, including the morale problems associated with the shift to a more authoritarian management, but the most damaging cause for the exodus was inadequate housing. An Office of Industrial Survey report for the year 1947 assessed the effect:

The importance of housing to the Station cannot be over emphasized. It is probable that turnover costs due to housing alone ran \$750,000 or conservatively at \$500,000 per person for 1947, plus twice that much in terms of quality of personnel available. Turnover among personnel adequately housed is probably lower than the national average. It is believed that housing is far more important as a recruitment factor than what has been considered to be adverse location factors, except for a few categories of professional positions, as now consistently available when housing is available.

It is believed that the amount spent for each house would return to the Government within five years in reduced overall administrative costs and improved performance. Most important, adequate housing would place the Station in a good position to take strong measures to improve the quality of personnel in all categories.¹⁷

The housing problems, in fact, had existed since the first few Quonset huts were erected at Harvey field in the winter of 1943. Almost without exception, every "early-timer" living today can describe some unusual conditions under which he was housed or under which he commuted in the early days. As John Richmond put it, "We never had enough houses."¹⁸

A housing and community problem was the price the Navy had to pay for locating in a virtually uninhabited desert area where it could have the space needed for weapon testing. This meant that the Navy had to provide shelter for sailors, marines, Waves, civilian scientists, engineers, and technicians plus dependents. Initial plans also had to include a sizable construction camp for contractors.

The complexities of the problem become apparent when the question is asked, Why were there never enough houses? Part of the

answer was in early failure to visualize the size of the Station relative to the planned technical work and to comprehend the magnitude of the housing and community needed. In 1943 Burroughs foresaw an "estimated ultimate population of about 1,000";¹⁹ two years later, this figure was seven times as great. If the early population estimates had been more realistic, it is likely that significantly larger funding for the community would have been forthcoming. This would have been possible because of the high-level support the new desert Station had and because of the greater mid-war flexibility in funding. At the war's end, new housing was a hard item to sell to a government with surplus buildings in other locations throughout the nation.

During the wartime years, the housing problem had seemed to be less severe. There were barracks and dormitory buildings—albeit often overcrowded, deficient in cooling and heating, and representing the stark austerity of wartime temporary construction. The ubiquitous Quonset served an infinite variety of purposes; from sleeping quarters to chapel, from offices to schoolrooms. Even so, the demand for shelter always outweighed its availability. The lists of people awaiting housing were invariably long. During the waiting period, husband and wife were often separated and compelled to dwell in segregated dormitories; more often than not, their children lived "with Grandma" at a far distance from the parents. Other families more accustomed to the peripatetic life in wartime America stayed together, surviving the rugged climate of the Mojave Desert in trailers, or such "shanty" type of accommodations that they could construct or that might happen to be available.

But it was wartime. Family separations and rough living were to be expected; they were accepted phenomena of the era.

Almost overnight social values changed, and after V-J Day, former standards became unacceptable. Now, a return to the more conventional and comfortable way of life superseded personal goals of patriotic duty. If such a way of life was unavailable at NOTS, it was time to leave. As time went by, the newly emerging aerospace industry started to offer some attractive alternatives to a continuation of wartime living conditions in the desert. This accounts, in great part, for the huge personnel turnover in 1947.

The Navy's housing problem would have been significantly reduced if the private sector of the economy and other government agencies had realized that the Station was indeed what the Bureau of Ordnance said it would be, namely, *permanent*.

Throughout the nation military bases were being closed, and few developers distinguished between NOTS as a new research,

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development, and test center and wartime military training and operational bases. The few who did inquire raised the question, "What guarantee does the Navy offer that the Station will be permanent?" It fell upon the NOTS Commanding Officer to serve as Navy spokesman to those who questioned. A typical case is shown by a letter to the Ridgecrest Development Company on July 8, 1946:

This is to inform you that the Naval Ordnance Test Station Inyokern, California, is a *permanent activity* [emphasis in original] of the Naval Establishment representing an investment approaching the order of \$100,000,000. Its primary function of research, development, and testing of weapons is expected to be continued at the present scale. Enlargement in some fields of research is foreseen rather than reduction in any field, and research activities are expected to increase greatly with the completion of current laboratory and other building operations which involve expenditures of the order of \$12,000,000.

Very sincerely yours,
J. B. Sykes
Captain, USN
Commanding.²⁰

Only a few developers were convinced, and their limited investments in Ridgecrest houses and businesses were of relatively small consequence in solving the Station's problem. Nevertheless, they were important beginnings in the long-term conversion of Ridgecrest from a village to a city.

One of the early developments was of 100 homes financed through the Federal National Mortgage Association, familiarly known as "Fannie Mae."²¹ However, these were poorly built, and it is reported that a large number were foreclosed at the expense of the investors. As a result, this increased the skepticism of other potential investors and the Federal Housing Administration on the wisdom of investing in Ridgecrest. It would be decades before it was generally accepted that the Navy was not merely paying lip service to their avowal that NOTS was to be a "permanent activity of the Naval Establishment."

A remarkable degree of effort and cooperation was exerted by NOTS and the Bureau of Ordnance in trying to solve the housing problem. One effort was recalled by Richmond:

One day Captain Byrnes called me from the Bureau and said, "Well you fellows are always yelling for more housing, I'll give you two hundred trailers or two hundred pre-fabs, what do you want?" And I said, "Well I don't like trailers, Captain; however, I'll check with Captain Burroughs." . . .²²

Burroughs agreed but immediately began planning how to minimize the negative effects of the cheap prefabricated house. As Richmond recalled:

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... He [Burroughs] didn't like the idea of a bunch of pre-fabs on a permanent Station so finally he got hold of Sandquist and said, "All right, we got 200 pre-fabs coming here, but I want them built as far away from the community as possible, so that sooner or later—in a couple of years or so—we'll tear them down and throw them away and have more permanent housing on the Station."²³

Burroughs was particularly energetic in his efforts to mitigate the acute housing shortage. One day, while visiting the town of Bishop some 100 miles north of the Station, he became aware of many empty dwellings that had formerly been part of the Vanadium Mining Company. He promptly called the Bureau of Ordnance and arranged the relocation of these houses. As Richmond remembered:

We brought them down on flat-bed trucks in sections and rebuilt them. They were slightly better, maybe, than the pre-fabs, but not an awful lot.²⁴

These houses were henceforth known as the "Bishops."

The Bishops would be joined by other houses with special names, such as Duplex, LeTourneau, Normac, Wherry, and "Pink Brick." Each had its own story and represented a small individual victory in the larger bureaucratic battle to build the China Lake community; moreover, each played its own role in helping NOTS to acquire and sustain its staff. But after the addition of each new increment, the supply so lagged behind the need that Richmond's statement still held, at least until the early 1970s, "We never had enough houses."

ORGANIZATION: A KEY PROBLEM

Organizational changes were such a common part of NOTS early history that it was even suggested that the Station's initials stood for "Naval Organization Test Station." There was then nothing particularly unusual about a call for reorganization in December 1945 other than the fact that it had been only nine months since March 1945, when Thompson introduced the organization designed for NOTS postwar operations. But these were months of great change: the end of the war in Europe had set in motion the massive transfer of OSRD to the military forces; this transfer was accelerated with the end of the war on all fronts in August; locally the job of recruiting and building a civilian staff was moving at full pace; and a new Commanding Officer took the helm.

* As testimony to the long-term problem of NOTS housing, it is to be noted that "temporary" prefabs remained in service until early 1962.

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Another of the changes was the establishment on August 4, 1945, of a Research Board through the initiative of Thompson and with the approval of Burroughs just prior to his departure. The Board was to have the "general responsibility for the establishment and direction of research and development programs at this Station..."²⁵

Thompson wanted the Board in order to solidify the posture of the NOTS scientific and engineering staff and to give them a loud voice regarding research and development technical matters that needed command attention.²⁶

The role of the Research Board was accepted by Sykes, and there is little doubt that in certain ways he appreciated the advantage of the civilian scientists' expertise in technical matters. But at the same time it was clear that the Research Board's responsibility for "the establishment and direction of research and development programs at this Station" was unusually broad.

The vigor and strength of the Research Board during the early postwar years are easily understood when its original membership is considered: Wallace Brode, Bruce Sage, J. T. Hayward, and L. T. E. Thompson, Chairman of the Board.

A remarkable degree of harmony appears to have characterized the convocation of strong-minded men that comprised the first NOTS Research Board, although it is recalled that a spirit of candor often sparked their weekly meetings. The prime ingredient for success as a cooperative and highly effective team was the special kind of leadership and control exercised by its chairman. As a former Research Board member later recalled, "Thompson was so completely aware of the weaknesses of these... guys and of their strengths, and so dedicated that he was going to get them to work together, that he spent the time necessary to do it."²⁷

All the members of the Research Board were in the middle of the action at the end of 1945 to reorganize the Station, whereas the original organization for the postwar era had been fashioned by Thompson alone aided by occasional discussions with Burroughs.

As with the earlier organization, the Station was to comprise two major areas: Station administration on the one hand, under the Executive Officer; and research, development and test (RD&T) controlled by the Director of Research, Development and Test. Both the Executive Officer and the Director reported to the Commanding Officer (see Appendix E).

RD&T was to consist of five major departments: Science (Dr. W. R. Brode), Ordnance (Dr. R. A. Sawyer), Explosives (Dr. B. H. Sage),

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Experimental Operations (Commander J. T. Hayward), and Navy Liaison (Commander J. A. Duncan).

Among changes from Thompson's March 1945 chart were the elimination of the Associate Director's office and the incorporation of the Field Operations Department (now Experimental Operations).

Consideration of the changes in detail is of doubtful value. The special key to the reorganization's effectiveness depended on its being administered in the spirit of military-civilian cooperation outlined by Thompson in presenting the earlier organization. The aim was the same—to have a civilian technical organization operating with broad scientific freedom within the military structure. But this subtle balance required a special kind of mutual understanding that would frequently not be present in the months following the December 1945 reorganization.

In fact, mutual understanding diminished. The result was the need for dialogue to arrive at a workable system. At the time, the primary vehicle for discussion was the Research Board, whose composition other than the commander was the civilian scientists. In addition to those previously mentioned, Dr. Arthur Howard Warner from the Massachusetts Institute of Technology joined the Board in March 1946. Warner became head of the Experimental Operations Department, formerly headed by Hayward, and he also became another advocate of civilian direction of the technical effort.

There was a need for a policy board that went beyond the technical efforts. In a memorandum of March 5, 1946, Sykes created the Administrative Board. Members initially included Maintenance, Experimental Operations, Executive, Medical, Personnel, Communications, Security, and Supply Officers; CO Naval Barracks; CO Marine Barracks; Senior Chaplain; and the Director of Research and Development.

It is interesting to note that the first members of this Board were predominantly military, since the only civilians were the Director of Research and the Civilian Personnel Officer.

The purpose of the Administrative Board was to advise and make recommendations in matters concerning basic policy for the Station. But since a great many administrative actions vitally affected the technical programs and could not be decided without knowledge of the programs, Sykes was forced to add technical managers to the Board. Consequently, membership changed considerably. Several naval officers (Commanding Officers of the Naval and Marine Barracks, Security Officer, Chaplain, Communications Officer) were dropped

from the list, and their places were taken by the civilians in charge of the five major departments. Now in essence, the Research and Administrative Boards shared almost a common membership, and the latter eventually withered as a decisive body. But during the middle of 1946, when both Boards were active and meeting regularly, it was quite difficult to separate the topics into "administrative" and "technical" categories. Moreover, the problems often had the same roots: housing, personnel, transportation, and budget. All these topics recurred many times in the official minutes of each Board meeting, particularly housing. But it was the topic of "organization" that prompted an early confrontation between the Commanding Officer and his staff.

It was August 26, 1946. The first postwar organization chart had been in effect for about nine months. Progressively during that time it had been woefully apparent that the NOTS problems, far from diminishing, were growing and multiplying. Hayward, Thompson, and Brode on the occasion of this particular Administrative Board meeting were quick to stimulate a discussion about new organizational plans that were in the offing.

Both NOTS and the Naval Ordnance Laboratory (NOL) had been asked by the Bureau of Ordnance to revise their organizational plans. At this time, the new plans were in a tentative state and undergoing local review. The NOTS Administrative Board was highly interested in a copy of the NOL plan that showed that the Technical Director (a civilian scientist) enjoyed an unusually high degree of authority and control. The civilian was the distinguished scientist, Dr. Ralph Bennett. The NOTS Administrative Board apparently thought that the proposed NOL organization implied some kind of precedent that could be applied to Inyokern. The minutes indicate that Sykes did not agree.

Captain Sykes suggested that some time in the future the Station might be set up as a different type of Naval Station than any that exists now. At some future date the Station may be set up with a civilian director who would have a commission to take charge, but it is not that way now. . . . Dr. Brode stated that the Navy Department is apparently trying to set up certain research and test facilities under organizational systems which have been used by similar agencies, such as the Bureau of Standards, N.A.C.A., and the Naval Ordnance Laboratory.²⁸

The Board members then turned their attention to the new organizational plan proposed for NOTS that was patently a replay of the previous one; a command structure that failed to specify the scope of authority and responsibility of its key elements. Reluctantly, the Board recommended approval of the plan, but further

recommended that its submittal to the Bureau of Ordnance be withheld until Dr. Thompson returned to the Station.

Thompson's trip to Washington in August 1946 was propitious in more ways than merely providing a delaying action on the new organizational plan. During his visit, he had the opportunity for lengthy chats with his old friend George Hussey and another old friend from the Dahlgren days, Malcolm Schoeffel—now a Rear Admiral and recently appointed Deputy Chief of the Bureau of Ordnance. Thompson convinced both officers that NOTS needed a "charter" to attract and hold scientific mind of the same high level that had worked for OSRD during World War II.²⁹ Thompson was asked to draft such a charter.

At this particular time, Hussey was highly receptive to such ideas, as NOL was about to move to its new location at White Oak. He was giving a lot of thought to both NOL and NOTS and was considering the manner in which both laboratories would best fit into the total defense picture. Hussey's own wishes, according to Schoeffel, were to organize both establishments so that the technical people did the thinking and work, and the military personnel gave the administrative support.³⁰ Hussey was interested not only in giving joint responsibility to the Technical Directors and Commanding Officers of NOTS and NOL, but also in giving the laboratories a large voice in directing their own work. He saw the emergence of NOTS and NOL in their new postwar roles as a means of getting the weapon designing out of the Bureau's Washington headquarters and into the laboratories. While establishing his position, Hussey was listening patiently and equally to the proponents of different philosophies within his Bureau of Ordnance. When he asked Thompson to draft a charter, he asked Ralph Bennett of NOL to do the same.

The responses were quite different. Schoeffel later reported with a smile that the statement from Inyckern was "something like the Declaration of Independence" as it was in broad, general terms, but the NOL draft was much more specific, more like the bylaws of an organization.³¹

The "Declaration of Independence"—like its worthy and historic namesake—was a simple document in straightforward terms. Yet its very simplicity has enabled it, and the subsequent revisions, to provide clear guidelines under which NOTS, and later the Naval Weapons Center, would be managed. While its authorship is not precisely certain, it can be assumed that contributors included Drs.

Warner, Sage, Brode, and John Shenk, and Commander Hayward working under the leadership of Dr. Thompson. Its title was "Principles of Operation." Hayward later stated, "It was all in blue ink . . . but it should have been in red because part of it was my blood, and a lot of it was Dr. Thompson's blood."³²

The full text of the Principles is given in Appendix E. What we should note here is that the definition of the authority of the Commanding Officer recognized that the mission, civilian population, and isolated location of the Station resulted in complex and unusual administrative problems. For that reason certain boards and positions were established "to which the Commanding Officer will delegate the requisite responsibility and commensurate authority." Of special importance in this respect was the description of the position of the Technical Director, who, according to the document, "shall be delegated control of the research, development, and training activities, including methods of conducting research." The Principles were written to meet the long-term needs for a management philosophy assuring technical direction by the technically qualified. However, there was no doubt by the authors that the Principles were also pointed toward the solution of immediate problems.

Sykes, too, knew that they were pointed at limiting his command prerogatives. He reviewed the first draft some time in late September 1946; his rather strained but urgent letter to Hussey was dated September 30. The letter appears to be in the spirit of compromise. In it Sykes states his policy for NOTS, "technical personnel [to] work under the freest conditions . . . technical supervision [to be] restricted to general guidance . . . Station administration [to be] within the framework of Navy regulations, Public Law, and existing directives . . ." But he ended with the thought that the proposed organization did not need to be legalized, "but rather that the standard principles of naval organization as now applied should be continued and this application perfected, so that the technical personnel can give the maximum of their time to their technical work."³³

Hussey reviewed this letter and the proposed charter submitted by Thompson, although it was not yet signed by Sykes. On October 21, 1946, he approved the Principles of Operation without amendment or change. It was a historic decision in the relations between science and the military, for this was a revolutionary compromise designed to allow a strong measure of scientific freedom and initiative within the overall framework of Navy administration. It

would not only profoundly affect the character of NOIS, but it would also ultimately influence the philosophy of operations at both military research and development centers. The fact that the Principles were shaped to meet critical, existing management problems and forged in the heat of controversy made them all the more effective as realistic guidelines for the future.

After signing the document, Hussey returned it to NOIS with the request that it also be signed by the Commanding Officer. This was done by Sykes in the spirit later described by Hayward, "Like the good sailor he was, he accepted it."³⁴

Undoubtedly, Hussey had been subjected to many pressures by people from within and outside the Bureau of Ordnance, not the least of whom was his old friend Dr. "Tommy." It was postulated that Thompson had strong support from the giants of the scientific community. Hayward later commented in retrospect, "I'm sure Tommy mustered everybody and his brother including Hafstad and I've to talk to Hussey on this."³⁵

But at Invokert in the fall of 1946, the whys and wherefores of Hussey's decision were of relatively little concern. Much more important, the Principles of Operation had been approved. The NOIS scientific team had their "Magna Carta."

WEATHER STILL STORMY, OUTLOOK FAIR

A salient characteristic of Captain Sykes, it may be affirmed, was "quick to appraise a situation and readjust his thinking accordingly." As a former NOIS scientist recalled:

He was a very logical individual. If you could get him with a problem and not pull any punches. If he realized he'd been wrong, he'd say so and be done.³⁶

But it would be incorrect to assume that at the time he signed the Principles of Operation he considered he had been wrong or that any but procedural changes should be made on his part. He promptly took the necessary actions to promulgate the new roles for the Technical Director, the Administrative Board, and the Research Board. He gave no sign of any sensitivity to the fact that George Hussey's pen had diminished his direct control of the technical programs.

It could be debated whether the next round of difficulties was precipitated because Sykes balked just short of the goal or because Thompson pressed his success too far. The key point at issue was the desire of the technical staff to have the Technical Director or the

Research Board (of which the Technical Director was chairman) see all new orders, regulations, and administrative procedures before they were issued by the command. This philosophy was elaborated in a letter to the Bureau of Ordnance, prepared by the Research Board members on September 26, but it had not accompanied the Principles of Operation when these were submitted to the Bureau.³⁷

Thompson felt that the letter effectively fleshed out the bare bones of the Principles and helped to clarify the spirit of cooperation necessary for the plan to work well; therefore, it should be forwarded, albeit, *ex post facto*. Sykes did not agree, the letter was not sent, and a flurry of correspondence started between him and Thompson over the issue.

In the meantime, there appeared on the NOTS scene on October 29 no less a person than the Secretary of the Navy James V. Forrestal who would aid in establishing the spirit of cooperation inherent in the Principles of Operation. Some people, including Admiral Hussey who accompanied the Secretary, felt that this particular visit was unusually significant, in fact, Hussey called it a "bowling success."³⁸

The highlight was not in the formal tour of the Station or the review of programs, rather it occurred at a reception held in Captain Sykes' quarters. In this social atmosphere the Secretary had the opportunity for exchanges at a personal level with both the senior military and civilian staff of NOTS. And it was an opportunity for those of NOTS to present problems and philosophies to the highest level of the Navy. Most important, the thorny matter of military-civilian relationships was openly and frankly discussed. Throughout the evening there was an obvious rapport between the scientists and the Secretary. This and his interest in NOTS programs testified to the Secretary's appreciation of the need for the kind of military-civilian team envisioned in the recently signed Principles of Operation. Forrestal's support probably helped to get Sykes to embrace the Principles of Operation in spirit as well as in fact. But that was not an immediate result, for within a few days of the Secretary's visit, the Sykes-Thompson argument over the unsent letter was continued.

On November 8, in answer to a strong memorandum from Thompson who was still pressing for submittal of the Research Board letter, Sykes pointed out that the Principles of Operation had already been approved, and that the letter "is unnecessary for the purpose of establishing (the Board's) recommendations." He added, "If, however,

it is still desired that the letter be forwarded'. I will do so with nonconcurrency . . ."³⁹ From Sykes' standpoint, this appeared to be the bottom line!

Thompson seemed to recognize the impasse. Four days later, he again took up his pen. In his typical style, he pressed the point in two ways: first, in a formal letter to the Commanding Officer, and second, in a "Dear Jimmy" informal covering letter. In the former he wrote:

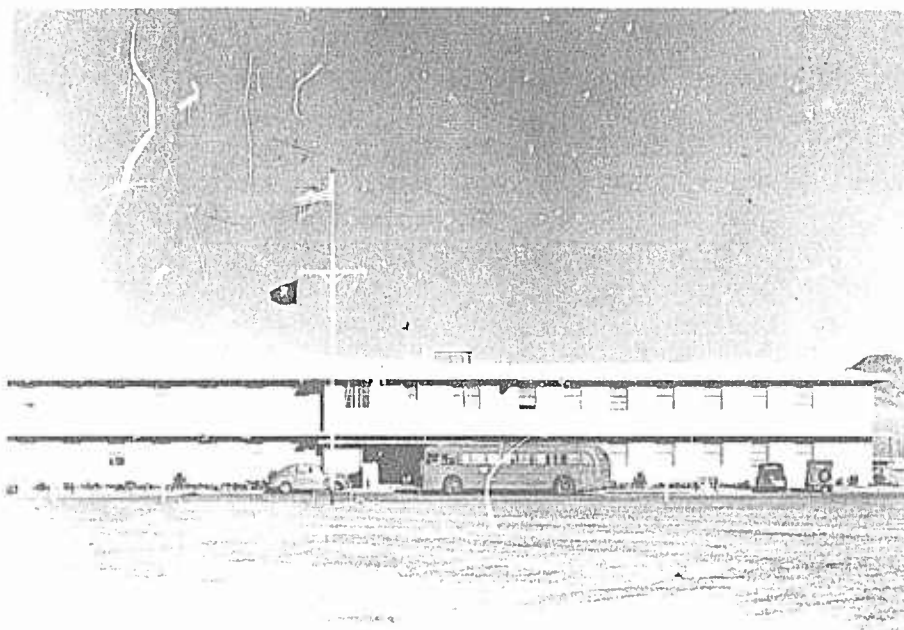
The point is not that rules and regulations and disciplinary action are unnecessary, but rather that tough military techniques in promulgation are not acceptable to the type of people on which the station is dependent for successful operation.⁴⁰

In the latter he spoke from the heart. "We have the Principles, as you say, and presumably the organization. All that is left in completing the Charter for the kind of development center NOTS is supposed to be is to insure an understanding of the spirit in which the Principles must work." In urging this cooperation he wrote, "And I think you will see the day when you will be as proud of the contribution as of any you have ever made. For this is a grand experiment at Inyokern."⁴¹

The letters to Sykes were written on November 12, 1946, a day of unburdening for Thompson. On the same day he wrote to Admiral Hussey requesting that his resignation as Technical Director be accepted.⁴²

The reasons for the request were not, according to the letter, the result of problems, but rather "in part because of evidence of an unsatisfactory physical condition." But people who daily saw the exuberance with which Thompson faced life and work discounted the explanation of poor health, at least his own. There were other possible explanations. For one, it was generally believed that his wife, Margo Thompson, was not fond of the desert and preferred to live in the East. Also, as mentioned earlier, it was clear at NOTS and other government laboratories that the civil service pay for senior scientists at that time was inadequate. And despite Thompson's statements to the contrary, there was the likelihood that the continuous skirmishes with the command over the organization and Principles had had an effect. He may have felt that the main struggle had been won and that a successor could just as capably lead any follow-up skirmish action especially if his own resignation would help call the Bureau's attention to the critical nature of military-civilian relationships in the "grand experiment."

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First permanent Administration building, December 1946.

Hussey's reply to the requested resignation was predictable:

Naturally I am regretful of your decision to resign from the position of Technical Director, because I feel as I felt when I urged you to accept the position; that your background and your long Ordnance experience were unique qualifications. I can appreciate, of course, that you are entirely a free agent and while, once again, I shall regret your leaving, I shall not, of course, in the least stand in your way, and I wish you all success.

With the hope that I shall see you again before you finally take the step, I am, with much appreciation for all that you have done for the Bureau,

Sincerely yours,
George⁴³

But the final step would not yet be taken: the destinies of NOTS and L. T. F. Thompson as Technical Director would remain interlocked for another five years.

The reason for his change of heart has never been ascertained, but the fact that Thompson did win the eight-week-long "Battle of the September 20 Letter" was probably a factor. On November 21, 1946, Sykes endorsed the letter and forwarded it to the Bureau. NOTS not only had its Principles of Operation but also the letter clarifying the spirit of cooperation necessary to make them work and

the role of the Director of Research who was to be the embodiment of that spirit.

OLD PROBLEMS RESOLVED

While the new charter for NOTS represented a first major step in solving a host of administrative problems for the desert Station, there was nothing in the "Principles of Operation" that touched even remotely upon a couple of ancient problems that had the perennial knack of resurfacing. One of these concerned the unfinished business of legally acquiring the land on which a greater part of NOTS had been built; the other stemmed from the still unresolved issue of who was to control the NOTS Air Facility, the Bureau of Ordnance or the Bureau of Aeronautics.

As the temporary-use permit issued by the Department of the Interior for lands in public domain had specified that the lease was "to expire six months after the termination of the declared national emergency," a flock of contested claims came to roost at Inyokern in the early part of 1946 from cattle ranchers, homesteaders, and miners. In a wartime emergency, all of these could be docketed and buried in a "pending action" file, but now each case had to be painstakingly reviewed.

One viewpoint on how some of these cases were settled is that expressed by Duane Mack who was asked to accompany a bus load of jury members charged with deciding settlements to the various ranchers. His later report of this experience offers the following poignant commentary:

The desert takes over so quickly that the alfalfa fields were gone; the winds had leveled them you know, the weeds had grown up and the buildings were down. And it was pretty difficult to tell the jury, and I didn't feel the jury was really very interested, frankly, of how these people had lived and how they had strived to build up what little they had.⁴⁴

In October 1947 a congressional hearing was held by the Committee on Public Lands regarding the NOTS real estate. NOTS played a small part in these proceedings, largely because the key issues concerned the Department of Interior and also because the NOTS representative Captain J. H. Hean, played a passive role. Hean, the first U.S. naval officer to successfully fire air-launched rockets, was better known for his flying skills than legal acumen. Hean reported:

Many witnesses testified on behalf of their claims against the government relative to (a) undervaluation of their condemned property and

(c) failure on the part of the government to settle their claims. His testimony was aimed at the Department of the Interior mainly for their alleged delay in establishing the validity of claims, and, to a lesser extent, against the Navy Department and the Justice Department for alleged delay in settling valid claims.⁴⁵

So small was the NOTS involvement in the issues of discussion that the chairman approved Hean's request to withdraw.⁴⁶

On December 19, 1947, Public Land Order 431 granted the Navy clear title to Station lands formerly in the public domain. By this time, NOTS was well established as a major research and development center of the postwar Navy. Legal ownership of the land represented the capstone of the complex edifice so painstakingly constructed during the wartime years; it was a further guarantee of permanency for NOTS.

Another of the Station's land problems was ironically solved through inaction rather than by any legal struggle. This concerned the real estate of Harvey Field. As with the public domain lands of the Station proper, the old Inyokern airfield was on lease to NOTS for the period of wartime emergency plus six months. However, in this case, the pressing desire of the Civil Aeronautics Administration to get their field back was not matched by any tenacity of the Bureau of Aeronautics to retain it for their limited postwar purposes (Fleet training and target drone operations). There was virtually no contest, and in April 1946 the issue was dead. In a *Rocketeer* article headed "HARVEY FIELD CLOSING" (datelined NOTS, April 30, 1946) the turning of a significant historical page was sadly noted as follows:

Ringin' down the curtain on a 22-month career, Harvey Field was stripped of its remaining facilities* and reduced to an intermittent operational status last Friday. The remaining 88 men moved to China Lake Friday, and bus service was discontinued to the desert air station.⁴⁷

Before Harvey Field was closed, there were those who sincerely felt that many of the problems experienced by the Naval Air Facility stemmed from the dual air operations at Armitage Field and Harvey Field; that once the Air Facility was comfortably settled at Armitage Field and the Harvey Field situation resolved, the Naval Air Facility's problems would disappear. Unfortunately, such was not the case. Organizational problems continued to surface and bedevil the NOTS administration.

On April 9, 1947, Sykes wrote a personal letter to his old Academy classmate, Schoeffel; the letter is worthy of presentation in

* The "huge, roundshouldered" Kodiak hangar still survives, and apart from some desultory foundations, there is little other evidence of the Navy's former occupancy.

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full because a quick scan reveals the complexity of the NAF problems. He wrote:

Dear Malcolm:

The present command status of the local Naval Air Facility, Armitage Field, gives me considerable concern, and I should like to apprise you of the circumstances and request advice as to procedure.

SecNav letter 44-524, serial 134813 of 10 May 1944 established the Air Facility at this Station as an activity under an Officer-in-Charge, under the Commanding Officer, N.O.T.S., Inyokern. Accordingly, all aviation officers, except four, have been ordered to report to Commanding Officer, N.O.T.S. Two pilots and two non-flying officers have been ordered to the Naval Air Facility, reporting to ComEleven but not to Commanding Officer, N.O.T.S. Some enlisted personnel are ordered to the Naval Barracks, N.O.T.S., some to the Air Facility without reference to N.O.T.S.

General Order 245 of 26 November 1946, which I received on 10 March 1947, places the Air Facility under the military command of Commander Naval Air Bases, Eleventh Naval District.

My letter serial 904 of 11 March 1947 to OpNav via BuOrd requested return of the Air Facility under the military command of Commanding Officer, N.O.T.S.

A previous letter, my serial 581 of 19 February 1947 to C.N.O. via BuOrd, subject "Naval Air Facility, Inyokern", requested establishment of the Air Facility as a command under Commanding Officer, N.O.T.S.

The Secretary's letter 4-47-227 Op24 Serial 59P24 of 3 March 1947 places the Air Facility, Inyokern, under the management control of BuOrd. The present situation is this:

- (a) I have management control of the Air Facility.
- (b) I do not have military command or coordination control of the Air Facility.
- (c) Military command of the Air Facility should be being exercised by Commander Naval Air Bases, Eleventh Naval District.
- (d) My military control of Air Facility is only through the Commandant to Commander Naval Air Bases [Rear Admiral (later Vice Admiral) Calvin L. Durgin], Eleventh Naval District, and through him to the Air Facility.
- (e) Officers and men assigned to the Air Facility but not to N.O.T.S. are not under my military command.
- (f) All officers but four are assigned to N.O.T.S. and given duty at the Air Facility only by virtue of my management authority.
- (g) Jurisdiction in matters of summary courts is gravely in doubt.
- (h) I did and still do exercise military control over the Air Facility as if I were under the Commander Naval Air Bases, Eleventh Naval District, which as Commanding Officer, N.O.T.S., I am not.

The whole matter can be completely resolved and legalized by approval of the request in my letter, serial 581 of 19 February 1947, referred to above, which requested that the Air Facility be established under Commanding Officer, N.O.T.S., as it was before. The date of this action should be that of General Order 245, 27 November 1946. Otherwise, the Air Facility will continue to exist as a separate unit surrounded and supported by this Station but not under the Station's military control; orders for Air Facility personnel both Officers and men will all have to be changed and the complexities of administration and operation will be enormous and unnecessary.

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The matter needs to be resolved as soon as possible. Commander Naval Air Bases, Eleventh Naval District, is very sensitive on matters of his military prerogatives, and having already been reproved by him for discussing direct with the Bureau a matter concerning military command of the Air Facility I hesitate to write further official letters in the matter without your advice as how to proceed in the best interests of BuOrd without irritating Commander Naval Air Bases.

With best wishes,

Sincerely,
J. B. Sykes⁴⁸

This letter was effective in portraying the absurdity of the complex command relationships for the Naval Air Facility and in bringing about a long-term solution. The channel by which the message went from Schoeffel is not known, but the result is clearly shown in a Secretary of the Navy directive of April 28, 1947:

This activity [U.S. Naval Air Facility, Naval Ordnance Test Station] under a Commanding Officer, is under the military command and coordination control of the Commanding Officer, U.S. Naval Ordnance Test Station, Inyokern, California, *and under the management control of the Bureau of Ordnance* [author's italics]. It is exempted from the Naval Air Bases Command, Eleventh Naval District. . . .⁴⁹

NOTS accepted this solution of a major problem with characteristic aplomb. On May 5 a brief ceremony took place in Hangar 1 at Armitage Field and the directive was read to the assembled crew by Captain Sykes. Commander J. M. Elliott then read his orders as Commanding Officer and placed the Naval Air Facility in commission.⁵⁰ Henceforth, NOTS and its Naval Air Facility would work together in a very special relationship rooted in the unique mission of the Station itself: research, development, and testing of weapons.

1947: PERSPECTIVE

The winds of change that had assailed the desert ship throughout 1946 continued almost unabated in 1947. The same winds also blew over Washington, D.C.; over the entire command structure of which NOTS was a part. In September James Forrestal became Secretary of Defense, and his former post of Secretary of the Navy was filled by John L. Sullivan. In July George Hussey retired, and the Bureau of Ordnance, the *de facto* parent of NOTS, came under the new leadership of Rear Admiral (later Vice Admiral) Albert G. Noble.

The year 1947 saw few changes among leaders at Inyokern. Key figures like Thompson, Sage, Ellis, Warner, Richmond, and others who had served as NOTS standard bearers remained; thus, the unique

essence and flavor of the Station and its operating philosophy were preserved and perpetuated. But the NOTS Research Board would miss the vigor and sometimes tempestuous drive of Wallace Brode, who was destined to accept a special assignment in Washington.⁵¹

The organization chart changed again in August 1947, some ten months after the Principles of Operation were put into effect. It was more streamlined: one that showed four departments instead of five. The former Ordnance Department was absorbed by the Experimental Operations Department, and Dr. Warner became the head of EOD, which now included divisions for Underwater Ordnance, Aviation Ordnance, Measurements, and Guided Missiles. Similarly, the Science Department was expanded to now include Laboratory and Technical Services, Applied Sciences, Ballistics, and Chemistry and Physical Sciences. First Dr. John Shenk, then Dr. C. T. Elvey assumed leadership of this department when Brode left.

The Explosives Department, still headed by Sage, experienced little change other than acquiring a fourth division called "Test and Service." However, changes were very much in the wind for the fourth department of NOTS, which was initially identified as "GT&R (General Tire and Rubber) Contract." This "department" essentially administered a contract for test engineering and manufacturing services performed for NOTS by GT&R at the Foothill Plant in Pasadena. By mid-1948, the fine machine shop in the new NOTS laboratory would be virtually complete. From now on NOTS could begin to phase its own engineering and production functions from Pasadena to Inyokern. Accordingly, in July 1948, the GT&R contract would be closed out, and the department—which had formerly merely overseen—would have full cognizance as the Design and Production Department under Mr. D. C. Webster as the first department head.

The year 1947 also witnessed many turnovers among the military personnel at NOTS. In June, almost exactly a year after first reporting for duty, Commander Beckmann, the NOTS Executive Officer, was relieved by J. A. Pritchard, who significantly had the rank of captain. There was also a new Experimental Officer when Hayward was relieved by Hean.

But possibly the most significant change was apparent when it was announced in the *Rocketeer* on August 6, 1947, that Captain J. B. Sykes would leave NOTS; his replacement was to be Rear Admiral Wendell G. Switzer. The announcement came almost exactly two years to the day after "Jimmy" Sykes had first arrived to assume command of NOTS; however, he would not actually be relieved by Admiral Switzer for another three months.

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The years 1945-1947 were turbulent, critical years for NOTS. They were the formative years of the Station as a permanent research, development, and test center as opposed to its earlier years as a wartime test station and support organization for CalTech. They were the years of contention between a management philosophy based on military tradition and one seeking a larger measure of scientific freedom. They were the years in which dedicated and veracious men on two sides of the management issue fought forcefully, and in the main tactfully, for what they believed.

And each, in his way, helped to shape and give substance to the grand experiment at Inyokern.

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FRCB Naval Weapons Center records stored at Federal Records Center, Bell, California

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29. Malcolm F. Schoeffel interview, April 21, 1966, p. 1. (NWC 2313, S-8.)
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31. *Ibid.*
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PROBLEMS OF THE POSTWAR WATCH

37. Letter (NP45/A3-1) from the Research Board, Naval Ordnance Test Station, Inyokern, to the Chief, Bureau of Ordnance via Commanding Officer, NOTS, September 20, 1946. LTET. (NWC 2313, 1-89.)
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39. Memorandum from J. B. Sykes to Technical Director, November 8, 1946. (NWC 2313, 1-79d.)
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41. Letter from L. T. E. Thompson to Capt. J. B. Sykes, November 12, 1946. LTET. (NWC 2313, 1-79a.)
42. Letter from L. T. E. Thompson to VAdm. George F. Hussey Jr., November 12, 1946. LTET. (NWC 2313, 1-92a.)
43. Letter from G. F. Hussey, Jr., to Dr. L. T. E. Thompson, November 21, 1946. LTET. (NWC 2313, 1-92b.)
44. Duane Mack interview, January 1969, pp. 27-28. (NWC 2313, S-60.)
45. Memorandum from Capt. J. H. Hean to ComNOTS on "Committee on Public Lands, House of Representatives, Hearing on Naval Ordnance Test Station, Inyokern, California," October 2, 1947. FRCB. (NWC 2313, 22-75.)
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48. Letter from Capt. J. B. Sykes to RAdm. M. F. Schoeffel, April 9, 1947. FRCB. (NWC 2313, 43-23.)
49. Unpublished manuscript history, "U.S. Naval Air Facility," by Administration Office, NAF, China Lake, May 23, 1967, p. 4. (NWC 2313, 15-12.)
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9

Headway in the Missile Era

Since the peacetime period following cessation of World War I hostilities some twenty-five years earlier, the nation had learned its lesson well. The World War II development of atom bomb, radar, sonar, advanced fire control systems, and rockets, among other items, demonstrated that the nation's security depends on continuing research and development programs to keep the armed forces in pace technologically.

As part of the postwar research and development effort, the rocket program continued to flourish at Inyokern. There was much to be done to refine the rockets hastily developed in wartime: the 5-inch HVAR, "Tiny Tim," and the aircraft spinners. In addition there was a long docket of minor ordnance projects outstanding that concerned the more conventional weapons—bombs, fuzes, explosives, and guns.

But the greatest challenges were to emerge from some brand-new weapon programs that NOTS fell heir to: advanced weapons for undersea warfare, aircraft rockets for air-to-air combat, and an entirely new ordnance discipline encompassing guided missiles.

CRITERIA FOR WEAPON PLANNING

One of the most important postwar questions was directly rooted in the dramatic events at Hiroshima and Nagasaki: had the ultimate weapon been achieved? If so, and the possibility appeared very real, would conventional weapons now become obsolete? The answer to this question was not only vital in the long range to national security but was of immediate importance to the future of Inyokern.

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The answer, however, was not immediately at hand, nor would it be for a long time.

The problem was to evaluate the new weapon with regard to different kinds of threats and the extent of its power as a deterrent. Wise men recognized clearly that much more needed to be learned about nuclear weapons before scrapping fleets and army divisions, pilot plants, and laboratories. In particular, the Navy was anxious to evaluate the effects of an atom bomb against its ship and other naval targets in general. Operation Crossroads, under the command of Vice Admiral Blandy, conducted at Bikini atoll in the Pacific on July 1, 1946, provided an opportunity.

What the Navy sought to refute at Bikini was a statement beloved of certain strategists that the atom bomb had rendered navies obsolete; a somewhat similar argument to that posed by Major General "Billy" Mitchell in 1921, regarding the efficacy of "iron" bombs. Specifically, the goal of Operation Crossroads was to determine weapon effects so that dispositions, tactics, and ship defensive measures could be devised to minimize destruction and demobilization.¹

Although Operation Crossroads provided a much-needed volume of technical data for the Navy to apply to a long-range planning program, it failed to support any conviction that navies were obsolete. And although Navy interest was stimulated, it is not correct to imply that interest in nuclear weapons did not exist prior to the Bikini atoll tests. On the contrary, Navy interest, especially that of the Bureau of Ordnance, had been stimulated early during the atom-bomb development phase and had been maintained through the crucial postwar nuclear tests. Of special importance was the leadership given in the postwar period by Admiral Parsons who, as the Navy's outstanding expert on the subject, had pressed hard for an aggressive Navy nuclear program. Tangible evidence of this interest could be seen in the brand-new pilot plant at Salt Wells—a viable adjunct of NOTS.

But if the Navy's interest in nuclear weapons was high in the early postwar years, it was tempered by a more pragmatic concern for the immediate needs of the Fleet in terms of advanced "conventional" weapons. This philosophy is aptly paraphrased by James Phinney Baxter III in his book, *Scientists Against Time*, written in 1946: "Until the world creates an international organization strong enough to control the genie who escaped from his bottle at Alamogordo, we must keep our powder dry."

This philosophy was generally ascribed to by military and political leaders in the postwar period. As a result there was not an abrupt cutting off of research and development funding after World War II as there had been after World War I. After V-J Day at NOTS Inyokern, "keeping the powder dry" could be more appropriately translated into "business as usual." Forward-fired aircraft rockets continued to be the mainstay of the Station's business. However, within the continuing research context of rockets and their potential for weapon application, people were thinking more and more about a relatively new kind of weapon: the guided missile.

In a future time in the Center's history—some years beyond the scope of this volume—the name "NOTS" would become as strongly associated with guided missiles as it had been with aircraft rockets in World War II. But while the Station's leadership in aerial rocketry was implied almost from its founding, such was not the case in the field of guided missiles.

It had been inherent in the thinking of Navy leadership in November 1943 that the NOTS mission statement should not be limited to any specific type of weapon, although an emphasis on aircraft rockets was implied. Nevertheless, strong forces developed to block guided missile development at Inyokern.

Accordingly, the efforts at NOTS to earn and acquire a future stake in this new and challenging field of weaponry constitute an important part of the Station's story.

STRUGGLE FOR COGNIZANCE

Throughout its early history, Inyokern appeared destined to serve as an arena for skirmishes between the two powerful and competitive Bureaus—Ordnance and Aeronautics; for example, the struggle for control of the Naval Air Facility during the war years. Similar clashes continued to be evident in the immediate peacetime years, too, and probably the most significant was over cognizance for guided missiles, a controversy that started long before there was a NOTS.

The Bureau of Ordnance had been the first to enter the new field during World War I, when, in April 1917, an appropriation of \$50,000 was made for experimental work on "aerial torpedoes in the form of automatically controlled aeroplanes or aerial machines carrying high explosives."² Interestingly, the Bureau of Ordnance termed its pilotless aircraft a "flying bomb," although the names

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"aerial torpedo," "explosive carrier," and "controllable bomb" were also used.

In January 1921 the Secretary of the Navy approved the development of radio-controlled aircraft by the Bureau of Ordnance and the Bureau of Engineering. Eight months later, however, the Bureau of Aeronautics was established. Its charter contained all that was necessary to claim cognizance of all aircraft, piloted or unpiloted; specifically, it called for "all that relates to designing, building, fitting out, and repairing Naval and Marine Corps aircraft."³

During the years between the wars, the challenges were rather desultory, principally confined to some strongly worded expressions of discontent by a few Bureau of Aeronautics officers. The Bureau of Ordnance carried on with its pilotless aircraft development programs and the Bureau of Aeronautics started its own program for a flying aerial target—a pilotless "drone" that could be remotely controlled by radio by an operator in a "mother" aircraft.

Shortly after the outbreak of World War II, the issue of cognizance heated up considerably as the scope and character of weapon development in the two Bureaus appeared to approach commonality. For example, in 1941 the Bureau of Aeronautics initiated the development of GLOMB (glider-bomb), a glider that could be towed long distances by a powered aircraft, released over the target, and guided by radio control in its attack. A little more than a year later, the Bureau of Ordnance had two similar developments under way: Pelican and Bat. Both were glide bombs, but with a significant added feature: *radar* control. Whereas Pelican—intended for antisubmarine use—failed to prove itself in operational testing, the Bat, designed for air strikes against land and ship targets, saw superb test scores and was rushed into combat.

Because of Bat's late arrival, there were few first-class naval targets left for it to destroy, but smaller ships merely offered a more severe test for the missile. One Japanese destroyer was sent to the bottom, followed by many tons of cargo shipping. But Bat was unique in history. It was the first fully automatic missile produced by any of the combatants. The Bureau of Ordnance estimated that the weapon represented "1,000 man-years of research and developmental effort."⁴

Interestingly, the term *guided missile* figured significantly in the cognizance battle between the Bureaus of Ordnance and Aeronautics that started to reach high peaks as the wartime development of these

weapons intensified. Both Bureaus felt that a more precise definition of terms might help the cognizance issue and agreed on the following:

A guided missile is an unmanned vehicle travelling above the surface of the earth, which is guided from the launching point to the target by command signals outside the vehicle, or by sensing equipment within the vehicle, or by a combination of these systems.⁵

If the new definition helped at all, it was the Bureau of Ordnance's cause that benefited most directly. In a conference on May 4, 1943, it was supposedly decided that "By an agreement with the Bureau of Aeronautics, the Bureau of Ordnance has cognizance over *all Navy Guided Missiles* [italics added] with the exception of drones."⁶ The reaction to this decision was predictably vitriolic.

The Bureau of Ordnance embraced the thesis that all weapons were the inalienable province of the "weapons" Bureau. The Bureau of Aeronautics doggedly held onto the contention that all winged vehicles were the special province of the "aircraft" Bureau as determined by its original charter; moreover, it counterclaimed that *no* bureau had complete control over any branch of science or technology.

As Rear Admiral D. S. Fahrney, USN (Ret.), commented in his unpublished manuscript on the subject, "... the fires of jealousy smoldered along all echelons in the bureaus and at times broke out in spectacular denunciations of the lack of consideration for the rights of one or the other."⁷

Despite all efforts, even at the Chief of Naval Operations level, to reconcile the guided missile cognizance issue, it was largely unresolved at the end of the war in 1945. In the meantime, the Bureaus of Ordnance and Aeronautics had essentially forged ahead with their own particular programs, regardless of category or whether the vehicles were "winged" or otherwise.

Thus, at the war's end, guided missiles under development by the Bureau of Aeronautics included Gargoyle, an air-to-surface rocket-propelled missile; Lark, a surface-to-air subsonic missile propelled by a liquid rocket; and the Gorgon IIA missile, an air-to-air missile using liquid rocket propulsion.

Missiles under development by the Bureau of Ordnance included Dove, a high-angle heat-homing bomb; Kingfisher, a series of jet-propelled air-launched missiles; and the Bumblebee series of surface-to-air missiles, also planned for jet propulsion.

From the above list, two missiles are of special significance to this account because much of their testing was assigned to the Naval

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Ordnance Test Station, Inyokern. These were the Bureau of Aeronautics' Lark and Bureau of Ordnance's Bumblebee. Both missiles were in the surface-to-air category—evidence that the cognizance struggle was still unresolved.

In November 1947 high-level decisions were made that were intended to settle the missile controversy once and for all. Rear Admiral Daniel V. Gallery, Deputy Chief of Naval Operations (Guided Missiles), conferred with the Chiefs of the two Bureaus and suggested that a natural division lay in the air-launched and ship-launched categories of missiles. As a starter to accomplish this plausible division, Gallery further suggested that the Bureau of Aeronautics turn over all development of surface-to-air missiles after completion of the Lark to the Bureau of Ordnance who, in return, was to give up "forever" any concerns with, or development of, air-to-air missiles—including Meteor, which had just gotten under way.

Despite the usual protests by the respective Bureau officers, Gallery's suggestion was accepted by the concerned Chiefs. It was a binding agreement that would last for some three years. During this time, the Bureau of Ordnance fulfilled the spirit of the agreement by enjoining its test station at Inyokern against any involvement in air-launched missile development.

If many officers of either Bureau failed to understand and accept this latest determination of guided missile cognizance, this lack of understanding was shared by many of the military and scientific civilian leaders at NOTS.

Having inherited the Navy's technical leadership in the development of rockets, the NOTS staff saw guided missiles as rockets with "intelligence," and as developers of aviation ordnance, they recognized guided missiles as the great promise in air-to-air warfare.

In 1945 the nation's principal expertise in rockets as weapons was centered at Inyokern. This embraced the total knowledge acquired by the CalTech group under Lauritsen when the torch was passed to NOTS at the end of the war.* In a very large sense, the capability of designing and developing flight controls and guidance systems was well represented by the able nucleus of scientists and engineers then on board. If this capability was all that was necessary

* CalTech had two rocket programs during the war. At the end of the war the Lauritsen program for military rockets went to NOTS and the von Karman-Malina rocket-research program became the basis for establishing the Jet Propulsion Laboratory of CalTech.

to translate an aerial rocket into a guided missile, then NOTS should have been one logical place to do it.

However, the NOTS bid for guided missile work was not a bid for cognizance, but quite the contrary. The NOTS philosophy was against artificial barriers that would obstruct new approaches to problems of national defense. This philosophy was parallel to that expressed later by Parsons, by then a Rear Admiral:

The words "cognizance" and "primary responsibility" sound attractive to those who measure achievement by neat looking organization charts and strongly-coordinated production and procurement programs. In air-controlled military and industrial organizations assignment of cognizance means that some individual or group has felt that it could "see around" the problem and therefore set boundaries and define (limit) the effort. The degree to which this can be done is in my opinion *inversely* proportional to the rate of development of the field in question. No one argues about cognizance of marlinspikes or saddles. But in important, partially exploited fields, cognizance can be synonymous with "paralysis" or "stranglehold."⁸

On October 20, 1946, Dr. Thompson had written a memorandum on the subject, "Task Group for Guided Missiles," which included B. H. Sage, W. R. Brode, C. T. Elvey, E. L. Ellis, W. B. McLean, W. N. Arnquist, and H. G. Cooper. The memorandum expressed Thompson's desire for NOTS to take a closer look at guided missile technology; first, to survey all of the nation's significant work on missiles, then to establish contacts with other guided missile developers "for the purpose of laying out a general program covering work in prospect at NOTS during the next six to twelve months."

Although not directly stated, the formation of the Guided Missile Task Group was implicit: to get "a foot in the door" of missile development. It is noteworthy that Thompson took pains to offer a logical and legal justification for founding the Group: ostensibly, to "provide an effective basis for continuing work at this station on certain components of guided missile systems." NOTS was already doing missile work of a different kind: testing. As a test station at the war's end, its ranges and facilities had already been destined for heavy usage in support of the Navy's primary guided missile programs: Bumblebee and Lark.

POSTWAR NAVY MISSILE PROGRAMS

Despite the advantageous posture enjoyed by NOTS as a test station "in being"—with an excellent potential to handle guided

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missiles—it was by no means the only one during the early postwar period. In January 1946 the Bureau of Ordnance established the Naval Air Ordnance Test Station at Chincoteague, off the Virginia coast, with a stated mission “to perform tests and modifications as necessary to develop aviation ordnance and guided missiles”;⁹ the establishing order also provided for the transfer of all Bureau of Ordnance guided missile test facilities and staff from the Naval Material Center, Johnsville, Pennsylvania, to the new Station. Upon hearing the news, some at Inyokern ironically noted that the “Naval Air Ordnance Test Station” name was the very one that had been advocated for NOTS some two years earlier.

In 1946 the Bureau of Aeronautics, too, reaffirmed its unshaken resolution to retain leadership in the guided missile field by establishing the Naval Air Missile Test Center at Point Mugu on the California coast to “conduct tests and evaluation of guided missiles and components . . .”¹⁰

Prior to the establishment of the Naval Air Missile Test Center in October 1946, a Pilotless Aircraft Unit was organized to handle one of the Bureau of Aeronautics’ major missile projects—the Loon, an American version of the German V-1 “buzz bomb.” The Unit was stationed at the Marine Corps Air Station, Mojave, California, from November 6, 1945, until October 1, 1946, when it moved to Point Mugu and was absorbed by the new test Center.

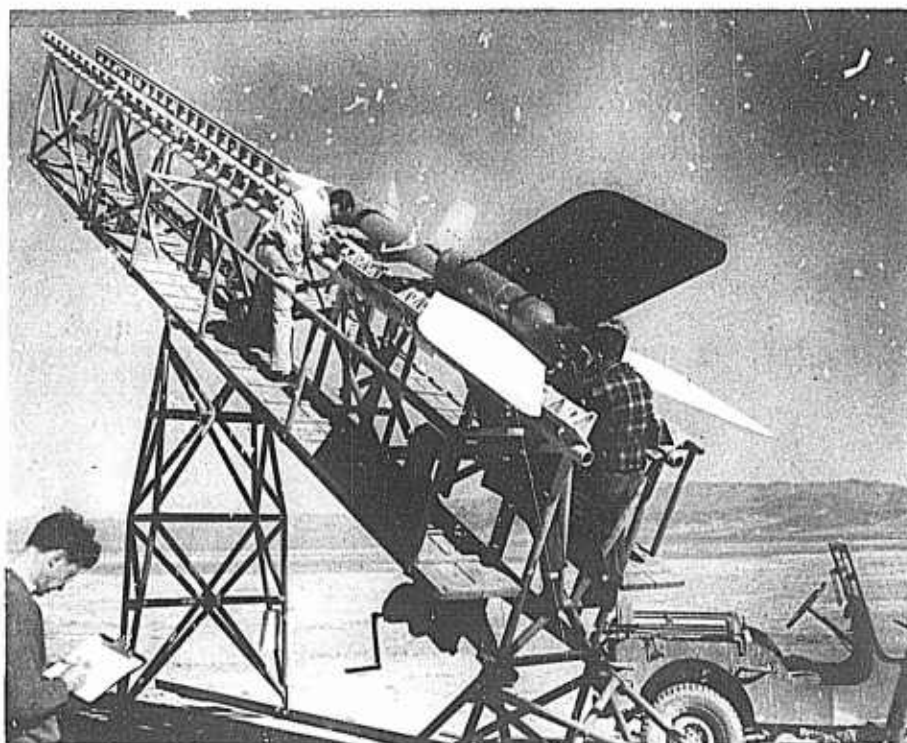
The establishment of the test facilities at Chincoteague and Point Mugu reflected the high degree of interest in guided missile development on the part of the Navy and recognition of a need for test stations to support their development. Unfortunately, while the testing of missiles appeared to have been provided for in the immediate postwar years, their research and development were not. Most of the Navy’s missile programs were started during the war under the management of OSRD. When that Office was dissolved, the status of these programs was extremely tenuous.

To put Bumblebee and Lark guided missile development on a sounder basis, the Chief of Naval Operations undertook a complete reorientation and consolidation of Navy guided missile development in early 1946. As a consequence, many programs were discontinued. Others, such as Gorgon II-A and III-A, were limited to test and research vehicles, as was Loon. However, it was decreed that Bumblebee and Lark would continue as high priority ship-to-air missile developments.

It is understandable why this priority was assigned to ship-to-air

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missiles. The heaviest losses borne by the Navy during the war—from Pearl Harbor to the kamikazi operations—had been caused by aerial attack. Also, with the defeat of the German and Japanese navies, no major surface fleet of a potential enemy was in sight.



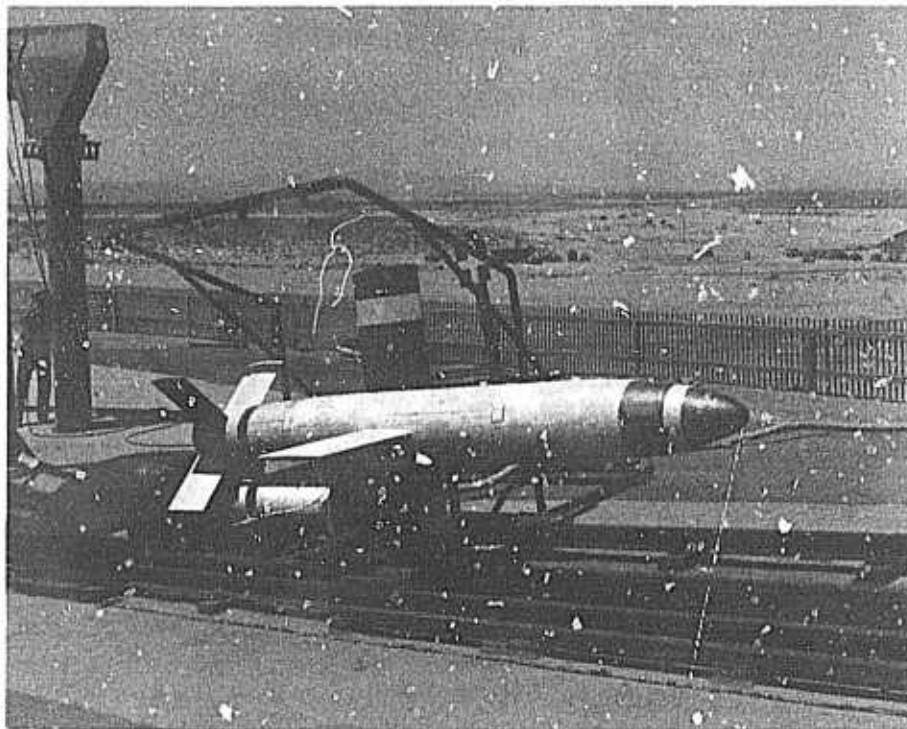
Bumblebee on launcher.

The Bumblebee and Lark programs each represented a different means for the Navy to continue its aggressive missile development effort: direct contract with a university-associated laboratory (the Applied Physics Laboratory (APL) of Johns Hopkins University for Bumblebee); or one of a growing number of aircraft manufacturers involved in such R&D projects (Consolidated Vultee and Fairchild for Lark). Among this latter group, which would eventually be known as the “aerospace industry,” there was already strong competition for government development work. And this competition grew as more large industries threw their hats in the ring. Not all of these companies were aircraft manufacturers. Some (such as Eastman

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Kodak, Westinghouse, and General Tire and Rubber) had built up facilities and technical staff during the course of wartime contracts with OSRD and had acquired a taste for government ordnance work.

As originally conceived by the OSRD Section T scientists, the Bumblebee concept was unique and innovative: a jet-propelled anti-aircraft weapon, rocket-launched from shipboard, and guided to its aerial target along a radar beam. From the first, the program was assigned top priority by the Bureau of Ordnance, even going to the lengths of withdrawing APL from the highly important proximity-fuze program to take over the development of Bumblebee. Among the many new technologies APL had to master was the development of a ramjet engine; that is, one that would obtain its oxygen from the airstream rather than an oxidizer. This was accomplished within six months.



Lark (KAQ-1) ready for firing on 450-foot ramp; Big Richard is used as booster.

The successful flight test of this first ramjet engine, demonstrating thrust at supersonic speed, was made on June 13,

1945, at Island Beach, New Jersey. The historic engine that powered this flight was only 6 inches in diameter and was reportedly constructed from the exhaust tubing of a P-47 (Thunderbolt) fighter aircraft.

From the onset of the Bumblebee development program early in 1945, it was manifestly clear to the developers and the Navy that a lot of unobstructed testing space would be required for the many rocket test vehicles to prove out the guidance and propulsion systems for the program and for the missiles that would evolve. Several possible sites were looked at on the East Coast, including the one at Island Beach, but the overall range distance at each site was determined to be insufficient; moreover, none had the sophisticated range instrumentation necessary for the planned supersonic testing phase. Conveniently, the Bureau of Ordnance had such an area at Inyokern. Consequently, the test program for Bumblebee was transferred to NOTS in August 1945.

The many obstacles to guided missile development at NOTS did not apply to testing. In fact, a major effort of the postwar period was in developing and instrumenting a major range for surface-launched guided missiles.

The first guided missile test range at Inyokern was G Range ("G" designating "ground"), one of the largest of the NOTS test ranges: a 10-mile-wide pie-shaped wedge of open desert extending as far as the Station's northernmost boundary—some 37 miles. The pie wedge was bisected down the middle, the western piece, designated G-1, was for ground testing of live rocket ammunition; the eastern piece, G-2, was for inert ammunition. By mid-1944 the ground ranges were only sketchily laid out. The first rockets had been fired on March 30 from G-2, and in April temporary wooden towers were built along the range boundaries to plot the rocket impacts.¹¹

As with all of the NOTS facilities, the master plan for the test ranges was to establish temporary facilities for immediate use, and then eventually replace them with permanent ones. However, as the war drew to a close, the abundance of construction funds correspondingly dwindled.

Although within ten years G-1 was destined to become one of the world's finest and most fully instrumented guided missile ranges, it was certainly not so in August 1945 when the first testing for a guided missile program began at NOTS where a modified old searchlight yoke was used for a launcher.

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At first, the Station effort was strictly limited to assisting the APL development personnel in the performance of their field tasks. Understandably, the NOTS testing staff knew very little about the missiles themselves; in particular, ramjet propulsion was a brand-new technology. However, they knew a lot about the use of ranges, how to track rockets in flight, and how to gather accurate instrumented landline and telemetry data. The modern concept of sophisticated, fully instrumented ranges had already dawned at Inyokern under Dr. Bowen, and it was apparent that the newly emerging test philosophies and equipment were as readily applicable to guided missiles as they were to rockets.

The Bumblebee program became progressively more complex. Development of a practical propulsion system was but one of many problems that had to be solved to realize an effective tactical guided missile. The ranges and velocities obtainable with even the best of propulsion systems would have little meaning if accurate guidance and control were lacking. Since available knowledge of the aerodynamic characteristics of a missile at supersonic speeds was, for all practical purposes, nonexistent, early flight-control studies utilized subsonic flight test vehicles. These vehicles kept flights in the lower velocity ranges where aerodynamic characteristics of the various designs could be evaluated more accurately, and the problems of recording and assessing flight performance were simplified.

Free-flight testing of control test vehicles for Bumblebee began in January 1946. Almost a year later the first successful subsonic beam-riding flight was made at the Station when a roll-stabilized control test vehicle followed a fixed radar beam for 16 seconds. By 1948 a half dozen successful beam riders had been launched, and several beam-following runs (with beam movement at the rate of 5 mils per second) had been made.

A historic milestone in guided missile development was passed in March 1948 when two successful supersonic beam-riding flights were conducted at NOTS. As far as can be determined, these were the world's first successful beam-riding flights at supersonic velocities.¹²

The Bureau of Aeronautics' Lark was a pencil-shaped missile 14 feet long and 17 inches in diameter. It had four wings and four tail surfaces and an overall span of 6 feet, forming two crosses set at 45 degrees to each other. It was powered by a liquid propellant rocket engine and was initially designed to be launched by two strap-on, 1,000-pound-thrust, jet-assisted-takeoff units. As an anti-aircraft defense weapon, Lark was designed to be shipboard-launched; it would then

be radio-controlled to intercept an enemy aircraft flying at 350 knots up to altitudes of 30,000 feet, anywhere within a radius of 40 miles.

Despite their different respective Bureau ownerships, Lark and Bumblebee had much in common. They had begun almost together, shared similar operational purposes (shipboard anti-aircraft), and had emerged at the close of hostilities as priority development programs. More significant to our story, the test programs for them constituted the early beginning of a brand-new career for NOTS.

In August 1945, when Bumblebee operations started at NOTS, the Bureau of Aeronautics decided to take up the Bureau of Ordnance's gratuitous offer of the previous year to "make Inyokern available to the Bureau of Aeronautics for [certain] . . . tests."¹³ The Lark missile, like Bumblebee, required development testing and needed the favorable environment that so uniquely characterized the desert Station: weather conditions suitable for uninterrupted testing; terrain that facilitated recovery of missiles so that components that failed might be found and recovered; and a location having a minimum of firing restrictions, such as proximity of the flight line to shipping lanes, towns, or other populated areas.¹⁴

The Bureau of Aeronautics had contracts with two companies to develop separate but similar versions of Lark. One, designated KAY-1, was made by Consolidated Vultee Aircraft Corporation; the other, KAQ-1, was undertaken by the Fairchild Engine and Airplane Corporation. The primary development test objectives for both missile versions at NOTS were "to determine stability and control characteristics . . . correct any obvious faults in flight and control characteristics, and provide data for missile evaluation in respect to tactical capabilities."¹⁵

The program priority was high, and everybody concerned—the Bureau of Aeronautics, NOTS, and the two prime contractors—was anxious to start as soon as possible. Nevertheless, it would be nine months before the first Lark missile would be fired at NOTS. The delay was quite understandable. This was a new technology, and there was a wide gulf between relative accomplishments in the laboratory and in the field. In the perspective of hindsight, this literal inability to get off the ground represented, in 1945, a potent argument for establishing a research, development, and test center, with close ties among all phases of the work.

In early 1948 the Bureau of Aeronautics took action for the eventual shifting of all Lark testing to the Naval Air Missile Test Center at Point Mugu. Officially, the major factors influencing this

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move were completion of instrumentation at the short, sea range at NAMTC, and the advantage of conducting test operations at a facility under management control of the sponsoring bureau.¹⁶

Lark began its phaseout during the last two years of its four-year stay at Inyokern. In 1948 only 14 missiles were fired as compared to 34 and 28 for the years 1946 and 1947, respectively. As the program phased out, the Bureau of Ordnance had several new guided missile test programs waiting to take its place: Dove, Meteor, and Kingfisher. However, the individual stories of these missile programs are chronologically beyond the scope of this volume.

Bumblebee remained the key guided missile program at NOTS and the one that would do the most in financing the development of the NOTS ranges with their extensive instrumentation. But at the time, the great future success of this program and its distinguished descendants, Talos, Terrier, and Tartar, stayed largely unforeseen.

NOTS AIR MISSILE

NOTS scientists in the postwar period saw with increasing clarity that, unless they took the initiative, the new guided missile work for NOTS would be patently more of the same—essentially testing the results of other people's research and development effort. More important, it was becoming increasingly obvious to the scientists that guided missiles offered the most likely solutions to many of the most important tactical requirements they were trying to meet with their rocket and fire control projects. It was the traditional case of having to fight with one arm tied.

As the scientists took stock of their growing resources, introspectively regarding the realm of shops, laboratories, ranges, test facilities, a settled community, and their own growth as a research team, impatience to exercise their full research and development potential began to show. The first major initiative was taken by Thompson's Guided Missile Task Group.

During the initial ten months of its existence, the Group undertook a comprehensive study of guided missiles: their past history, current development by government and industry, and their potential as weapons of the future. From this study, the Task Group team members (now under the leadership of Dr. Andrew Vazsonyi) concluded that a most effective role of guided missiles would be that of an air-to-air weapon. They went further: they formulated the

broad technical specifications for such a weapon. In the independent spirit of early NOTS, the team members were not inhibited by the interbureau struggle for guided missile cognizance.

On August 30, 1946, Captain Sykes forwarded the Station's first proposal to the Bureau of Ordnance for a guided missile that was to be 72 inches long, 8 inches in diameter, and to weigh 200 pounds. Under "guidance," the proposal called for "straight-line path, non-beam riding, coupled with a homing device to take effect at a range approximately 1000 yards from the target."¹⁷ The proposal began:

1. The Naval Ordnance Test Station believes it desirable to consider the development of an air-to-air missile capable of being launched at ranges from 5000 to 10,000 yards and carrying a sufficient charge to be lethal to aircraft when detonated within a sphere of influence of existing proximity fuzes.¹⁸

It was estimated that it would take approximately two years to develop the missile. To meet this schedule, about \$170,000 would be required for development of the rocket motor and the "control jets for stabilization"—plus the services of some 24 employees.¹⁹

The Bureau of Ordnance's reaction was lukewarm. In this period it was being deluged by guided missile proposals of all kinds—notably from the highly competitive private industrial firms that constituted the emerging aerospace industry. And there was also a mounting offensive by the Bureau of Aeronautics against the Bureau of Ordnance's alleged preemption in the missile field.

No action was taken on the historic NOTS proposal for more than six months, when, on March 28, 1947, the Bureau of Ordnance approved a program for an air-to-air guided missile. It was a thin authorization, however, as it stated that "no additional personnel and no additional funds would be provided at that time, but that it was expected that work in existing projects and funds already provided would cover the immediate needs of the program."²⁰

And so the first missile development program for the Station limped into being. It was called "NOTS AM" (for air missile), and the project had an undistinguished lifetime of approximately twelve months.

EARLY BLUEPRINT FOR A WONDER MISSILE

A mild-mannered physicist in his early thirties, Dr. William B. McLean of the Fire Control Section, Ordnance Department, watched the activities of the NOTS Guided Missile Task Group with interest

and read their studies with what he recalled later as "considerable disgust."

Although he had been named a member of the original group in October 1945 shortly after he arrived at NOTS, McLean was not an active member of the team. Primarily, he believed a wrong approach was being taken in the detailed study of other existing guided missile programs; also, he felt that the group's missile was becoming "too complicated."²¹ From the beginning, McLean had ideas of his own.

McLean's career at the desert Station was destined to be quite remarkable. In 1954, after nine years on board, he would become Technical Director and serve in that capacity for thirteen years. But in the annals of the Station's history and in the wider ones of naval ordnance and the aerial weaponry of the free world, Bill McLean was earmarked for distinction through a singular accomplishment that would bring considerable fame upon him and his parent station. This was an air-to-air guided missile called Sidewinder.

McLean was keenly interested in guided missiles long before he arrived at Inyokern. During his preceding five-year wartime career as a physicist at the Bureau of Standards, he worked hard on the Bat glide bomb, devising gyroscope systems for stabilizing the missile. He recalled in a later interview, "Bat was a pretty good missile... it could either have a radar or... [a] television looking forward, and it would stay on the target..."²²

McLean's views in 1945 were that guided missiles should be considered as ordnance rather than aircraft in determining which Bureau (Ordnance or Aeronautics) was to have cognizance. Years later he asserted, "I think most of our delays in getting good guided missiles, and a lot of the expense in the guided missiles that we have now, came about because they were treated as aircraft rather than as ordnance."²³ But he also had an optimistic personal philosophy in that "what is *right* will eventually come about."²⁴

In the early postwar years there were problems aplenty at NOTS to challenge him and occupy his time. These problems were germane to the flourishing aircraft rocket program that had been inherited from CalTech.

Through exhaustive analysis of rocket flights on the NOTS ranges, McLean's Fire Control Section found many things that caused errors, such as windscreen deflection due to the flexure of the aircraft structure. The team also found that even with a fire control system assumed to be perfect, there was no way for the system to accommodate the largest error of them all—one caused by movement of the target *after* the rocket had been air-launched. It became

obvious to him there would be no solution to the real fire control problem by anything that could be put in the aircraft.

In McLean's mind there was but one solution: find a means by which the rocket could correct its own flight trajectory. This spelled out some kind of integrated guidance system to provide control intelligence for the rocket—right up to target impact. And McLean set out to find a way to make the necessary additions to the rocket to enable it to fulfill its ordnance requirements. Thus, this early missile guidance exploration at NOTS was done within the purview of rocket fire control development.

In analyzing the problem, McLean visited various places where they were working on both fire control and missiles. He asked about problems being encountered and about possible design solutions to these problems.

McLean perceived that most of the problems encountered at the other missile activities appeared to fall into three major areas. The first concerned conventional missile design whereby the electronics and control systems were variously located throughout the missile. Since ordnance regulations precluded storing and shipping the missile fully assembled, the hydraulic and electrical connections between the parts of the missile could easily become damaged or corroded, or get dirty—thus leading to very poor reliability.

The second problem area identified by McLean was rooted in the fact that the dynamic range of the airframe control systems was universally very difficult to achieve. Because the missiles had to work at altitudes from sea level to 50,000 feet, and at airspeeds from a few hundred to many thousand feet per second, the airframe control surfaces had to be deflected over a very wide angular range with great precision.

The third general problem area reflected the difficulty of mechanically isolating the target tracker, or seeker, from the rest of the missile. As a consequence, any large missile maneuver disturbed the seeker and the missile guidance became highly erratic; this was particularly true of missile roll rate.

In seeking to solve these problems, McLean designed a heat homing missile with an infrared seeker incorporating new design concepts. Essentially, the electronic power source, seeker, and control system were to be confined within a single package that could be mechanically attached—much like a fuze—so that there would be no need for electrical connections. The result was that the fuze, propulsion, and warhead units could be stored separately, making it possible to assemble the missile just like a normal rocket.

Other brand-new design features were worked out by McLean, expressly aimed at solving specific problems identified earlier. Included was a control surface mechanism—the “torque-balance servo”—that automatically deflected the control fins to whatever angle (or deflection) was appropriate for the missile’s speed or altitude. This was done without needing to measure the fin deflection value.

There was also a new seeker tracker that was, itself, inherently a gyroscope, which made it imperturbable by mechanical forces resulting from its attachment to the missile. Moreover, the new seeker tracker control mechanism that caused the seeker to track in a coordinate system unrelated to the missile’s axes enabled the seeker tracker to remain “ignorant” of (and therefore unaffected by) airframe actions such as snap rolls.

Yet another remarkable aspect of McLean’s new missile was a compact, high-power propellant gas generator that supplied all the energy for both the control surface mechanism and the electrical components.

As McLean came to grips with the NOTS fire control problems, he and his team became increasingly aware that the effectiveness of air-to-air ordnance (bullets and missiles) would eventually diminish as aircraft speeds became greater; to a point where there could be no solution by fire control improvement alone. His early concept of a completely self-contained guided rocket missile became ever more strongly reinforced in his mind.

The problem-solving design concepts had provided some useful terms in a formula for such a weapon (compactness, refined servos, gyros, etc.). The big unknown factors, suitable tracking and homing, were soon to be resolved. And from the completed formula would emerge a *true* air-launched guided missile—an air-to-air weapon that would eventually revolutionize aerial combat on a worldwide basis. It would take its name from an ancient resident of the Mojave Desert—the Sidewinder rattlesnake.

It is a story that extends beyond the scope of this history, and one that will be fully chronicled in a subsequent volume. But during the years 1945-1948, the significant fundamental concept of Sidewinder took form. Although this early Sidewinder work was done in a period of restriction on guided missile programs at NOTS, McLean did not have any financial problems with the project. It was supported enthusiastically by Thompson, who transferred experimental funds to it for the initial efforts.²⁵ This work led to the formal proposal for Sidewinder made by NOTS in 1949. From that time

forward, the Station would become as well known for guided missiles as it was for aircraft rockets.

PEACETIME ROCKET DEVELOPMENT

In the spring of 1946 some 20% of the Station's activity was concerned with guided missiles, this effort being about evenly divided between Bureau of Ordnance and Bureau of Aeronautics projects.²⁶ Approximately 40% of the Station's work in the early postwar years can be attributed to the China Lake and Salt Wells Pilot Plants. Most of the remaining effort was in aerial rocket development, an active continuum of the busy war years at Inyokern, although the urgency that had underscored the wartime program was now greatly diminished.

The main rocket effort of the Navy was centered at NOTS. And unlike the missile effort, most of the actual development cognizance was also placed with NOTS.

The reason for the Station's preeminence in the field of rocketry is easy to understand: the major rocket programs had been handed over intact by CalTech to the Navy at the end of the war. The Bureau of Ordnance apparently maintained a high level of confidence in the management at Inyokern to carry on where CalTech had left off. The rocket programs that were to continue in the immediate postwar period had already reached an advanced state of development. For example, Holy Moses and Tiny Tim had been employed in combat, but the speed of their wartime development had precluded some badly needed refinements. Now there was time to accomplish these refinements. Other rockets like the aircraft spinner rocket (5-inch GASR) were in advanced development.

Thus, immediately after the war, the newly inherited development task for NOTS was to put the necessary finishing touches on a number of rockets whose development was essentially complete. Or so it seemed at first glance! As it later proved, there was infinitely more to the task.

As one way of improving the rockets, NOTS pursued a program started by CalTech to make the rockets lighter. Originally, the motor tube, which was exposed to the hot gas during the entire burning period, had to be constructed of steel to withstand the gases. So CalTech devised the internal burning propellant grain in which all the flow of gas down the rocket motor to the nozzle was through a

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central perforation. Now the propellant itself served to insulate and protect the case from heating; thus, aluminum cases rather than steel ones were feasible. But, in turn, the significant weight change altered the aerodynamic flight characteristics of the rocket. As a result, thousands of ground- and air-launched test firings were required to revise the established flight data.

Similarly, the design of warheads and fuzes needed reappraisal and improvement. In particular the proximity fuze offered a tremendous added capability to the effectiveness of aerial rockets; however, its adaption proved to be a formidable task. NOTS initially undertook a lion's share of the Bureau of Ordnance's fuze development program, and once more the plate and target ranges were busy, as were the personnel of the target drone unit, operating out of the old Harvey Field. Although of high intensity, this effort was short-lived; in February 1947, the Bureau transferred all fuze work to the Naval Ordnance Laboratory.

It soon became obvious to NOTS and the Bureau of Ordnance leadership that improvements to existing rocket weapons were not enough; new rockets were needed to keep pace with the dramatic advances made in the aircraft that carried them—the high-performance jet fighters.

Wartime fin-stabilized rockets were carried externally under the wings with various types of launchers. On the Lockheed P-80A Shooting Star (the first U.S. jet-propelled combat aircraft) such externally mounted rockets resulted in a corresponding loss of airspeed from 100 to 125 miles per hour at altitudes between 30,000 and 40,000 feet.²⁷ Accordingly, the demand was for internally carried stores: tubes contained either in the wings or airframe. Tube-launched spinner rockets, therefore, received a full focus of attention and a high priority.

The spinners continued to pose formidable problems to aerodynamicist and ballisticians alike. A NOTS physicist, Dr. William Reed Haseltine,* explained some of the problems to conference members of the Aeronautics Committee of the Joint Research and Development Board.

The basis of the trouble with spinners is that they depend for initial as well as later flight stability on their spin. In ground launching, translational velocity through air and spin velocity are roughly proportional throughout the flight. But in air launching—from the initial moment of

* Haseltine, formerly of Massachusetts Institute of Technology, University of Wisconsin, and Ordnance Department, U.S. Army, arrived at NOTS in 1946 and was a leading physicist at the Center until his retirement in 1976.²⁸

launching—the spin is low but velocity through air is high; so the rocket is in an unstable condition for a short time interval after launching, which permits large yaws. We have observed yaws as large as 60° , after which the rocket settled down.²⁹

Other design trails were also being blazed that hopefully would lead to an optimum of storage and stability. One of these was a design feature that had been used earlier in the Army's 4.5-inch M8 aircraft rocket. The designers of this rocket had originally responded to the Army requirement that their aerial rockets be launched from tubes mounted on the aircraft. Accordingly, they had devised folding fins, a system in which hinged, spring-loaded fins fold in behind the body of a round and spring open when the body leaves the launcher tube.

The idea was a good one. Unfortunately, the spring-actuation mechanism posed some problems. For a start, the mechanism was bulky and occupied too much space in the tube to allow for an optimum-size nozzle. Moreover, the mechanism—located about the nozzle—could hardly withstand the extremely high temperatures within the launching tube; this caused erosion and “seizing” of the folding-fin mechanism.

NOTS scientists and engineers took the basic idea of folding fins and applied dramatic improvements. Instead of a spring-loaded mechanism to open the fins, an internal piston arrangement was designed that was actuated by pressure generated by the burning rocket motor.* In the latter part of 1946, preliminary design studies confirmed the feasibility of the new folding-fin concept.

Clearly, the Bureau of Ordnance was highly impressed by the idea of folding-fin rockets. Shortly after the feasibility demonstration by NOTS, an applied research program on folding-fin rockets was established at the Station, and in March 1947, the Bureau of Ordnance requested development of a folding-fin version of the 3.25-inch fin-stabilized aircraft rocket (FSAR). Dr. Ellis later recalled details of the early development:

Initial work was at the 3.25-inch size because we had that size tubing and could quickly make experimental rockets. It takes months to tool up to make a new size tube, and none of the aluminum companies (Alcoa and Reynolds) could make tubes which met the needed tight specs for

* Credit for this idea and the patent holdings belong to A. S. Gould, a pioneer in rocket engineering who had hitherto performed significant design work for CalTech as a member of the Launcher Section of the Rocket Group.

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straightness, ovality, and uniform wall thickness. We worked with them (especially Reynolds) to help them get us useable tubing. The size (2.75) which was eventually adopted resulted from a study which determined the explosive charge needed to destroy the target, and the size rocket needed to carry that charge to the target with the needed ballistic properties. The wall thickness and other characteristics of the warhead were determined by the penetration characteristics specified by BuOrd. The fuze was entirely a NOTS development and has been adapted to many other uses since its original use...³⁰

But in 1947 this was just the beginning of a brand-new rocket development program for NOTS; one that would result in the addition of another name to the distinguished roster of Inyokern's aircraft rockets: Mighty Mouse, a fin-stabilized rocket that could be launched with rapid and deadly effect by a fast jet fighter. Originally developed for air-to-air use, Mighty Mouse evolved as one of the primary weapons for air-to-ground attacks.

Mighty Mouse was a small-caliber rocket only 2 3/4 inches in diameter and 4 feet long. Its official name was "2.75-inch FFAR (Folding Fin Aircraft Rocket)." The Bureau of Ordnance gave as desirable characteristics for the rocket (which was intended for firing in salvos of 25 rounds or more from tubular launchers) a minimum burn velocity of 2,000 feet per second and a payload of 1.5 pounds of high explosive detonated by a contact fuze equipped with a short delay.³¹ Active development of Mighty Mouse was begun with high priority in the spring of 1948.

It is interesting to note that the success of the initial exploratory development of Mighty Mouse in 1948 prompted three major U.S. airframe contractors during the same year to develop aircraft that would be armed with the new folding-fin rockets. By 1973, some fifty million of these rockets had been produced for the armed forces.³²

One of the most useful facilities for the development of the new rocket turned out to be the 1,500-foot track at K-2 Ground Range. On this track, which consists of two cold-rolled steel rails mounted on a continuous concrete foundation, the complete rocket and launch-tube assembly could be strapped to a sled and accelerated along the track by a booster rocket to the same speeds of a high-performance jet fighter in flight. At such speeds, the developmental rocket was then fired from its tube, and its behavior recorded on film by an array of special purpose cameras.

In addition to the folding fins for Mighty Mouse, there were numerous technological advances applied to other NOTS rockets. These included lightweight metals for rocket components, internally burning propellant grains, and improved propellants and warheads.

This last item was particularly significant. Gone was the wartime practice of adapting conventional shells and bombs as rocket warheads (for example, Holy Moses and Tiny Tim). Now warheads were being custom-made by NOTS as part of the overall rocket design. They were constructed of new materials and designed for a variety of new fuzes and explosives.

These improvements often transformed old designs into virtually new weapons. The 5-inch HVAR (Holy Moses), for example, acquired a velocity of 2,300 feet per second (over its original 1,350 value) and had its intended tactical use enlarged from air-to-ground attack to antisubmarine work. Eventually the Bureau of Ordnance would request that a follow-on version of this rocket be developed with folding fins, which resulted in the multiple-purpose, air-launched Zuni.

Throughout the NOTS aircraft rocket program, both in wartime and in the postwar years, a notable diversity was evident in the size of the weapons: 2.75-, 3.5-, 5.0-inch, and the "really big rocket," the 11.75-inch Tiny Tim. But Tiny Tim was by no means the largest aircraft rocket in the NOTS catalog. Immediately following its successful development, work was started on an even bigger one. This 14-inch rocket, called Big Richard, was an extension of the Tiny Tim design principles. The first models were built in the spring of 1945, but this rocket had not been air-fired by the end of the war.³³

Development of Big Richard continued at a low priority for about eighteen months after the war, and by January 1947 was reported as completed. Although Big Richard never made it to the Fleet, a number of developmental rounds were relegated to useful, if unspectacular, service as rocket boosters for Lark testing, and for the 1,500-foot test track at K-2 Range. Thus, it aided in the development and test of its more noteworthy family members.

In the postwar years, Inyokern's role as the Navy's center of rocketry was never abrogated. It was the center of a revolution in ordnance that was quietly taking place as rocket propelled weapons were replacing guns as the primary armament of the Navy. The NOTS role in this revolution did not escape public attention. The hitherto secreted Station became the subject of a spate of feature articles in the popular press. A typical article appearing in the *Saturday Evening Post*, June 29, 1946, was written by Frank J. Taylor and titled "The Navy's Land of Oz." *Life* magazine also featured NOTS in a lead article, "Rocket Town," in February 1948. That the Bureau of Ordnance saw NOTS as its center for rocketry is evident from the infinite variety of rocket-associated tasks that it allocated to the Station. Out of a total of 172 projects listed in a June 1946 status

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report of the Bureau of Ordnance, 108 directly relate to rocket development. The rocket ventures at Inyokern in the postwar years testified to a salutary fact: NOTS had quickly and surely assumed the mantle of leadership in military rocketry—for the nation and the free world. The grand experiment at Inyokern was succeeding.

And one of the dimensions of the experiment had to do with a field that appeared to be far removed from aircraft rockets.

UNDERWATER ORDNANCE

At first glance it seemed improbable and hard to reconcile; namely, that a major program of the Naval Ordnance Test Station, with its headquarters in the fastness of the Mojave Desert, should concern itself with *underwater* weapons! Moreover, the principal weapon of the program was a torpedo.

But those who found the situation anomalous were perhaps not aware that certain significant facilities possessed by NOTS were those self-same ones that had played such a large developmental role for Mousetrap, Minnie Mouse, and the MAD/retro system. These facilities were tailor-made for undersea ordnance work and, together with many of the former CalTech personnel who originally designed and built them, were now a vital part of the NOTS Pasadena Annex.

Thus, NOTS was firmly established in the underwater ordnance field from the outset and was remarkably well equipped to handle the development of antisubmarine weapons. The legacy from CalTech had assured this capability. But the same legacy embraced more than people and facilities; it included programs as well.

One of the most important of these was the torpedo program.

Like the aircraft rocket program, the torpedo program was handed over to NOTS intact for what is considered to be Phase II of the torpedo program (CalTech work from 1942 to 1945 is Phase I), and the Station was off to a good start in terms of qualified people and facilities already in existence.

The Bureau of Ordnance was vitally concerned about torpedo development. Widespread failures of air-launched torpedoes early in the war had left their indelible mark. The Navy's wartime development of torpedoes, including the CalTech work, had resulted in enormous improvement of torpedo reliability and performance. But at the end of the war, airplanes and submarines were much faster, and the increased launch speed meant stronger and lighter torpedoes. Ship-target speeds, too, were greater. Accordingly, torpedoes needed

new propulsion systems to make them run faster.

In regard to the need for improved propulsion, the lessons of the war had been learned well. Rarely was a ship hit that moved at more than half the speed of the torpedo launched against it; that is, a torpedo traveling at 40 knots toward a ship moving at 20 knots was usually wasted. The obvious answer to faster ships was even faster torpedoes, and in December 1945 the Bureau of Ordnance requested NOTS to institute studies toward that end.

In July 1946 the Bureau, using these studies as a criterion, requested NOTS to develop a 1,000-pound, high-speed, straight-running torpedo capable of being launched at 600 knots from a height of 10,000 feet. In addition, the new torpedo was to carry an explosive charge of 300 pounds at a speed of 120 knots over a range of 1,500 yards.³⁴

It was clearly an impossible order to fill and obviously far beyond the technology of the time. But the request served two useful purposes: it indicated that the Bureau of Ordnance was thinking far enough ahead toward future weapon development; and it helped the design and development team at the Pasadena Annex to set their sights accordingly. Even if what appeared to be the ultimate torpedo never materialized, at least the attempts to achieve it would greatly advance the state of the art.

There is evidence that scientists at NOTS had an equally distant aiming point regarding the weapons of the future.³⁵ W. H. Saylor, Head of the Underwater Ordnance Section in Pasadena, revealed some of this advanced thinking in a later high-level conference:

...Taken together, the guided missile work and underwater ordnance work, there is much that is very similar. The weapon of the future will have to fly through air and go into the water, and so we have prepared a plan for the Bureau concerning this. To achieve optimum effectiveness we are proposing the same propulsion components. Lithium makes this possible. We think this particular viewpoint of not having separate missiles for air and water, but just one that travels through the air and then goes into the water is one which is going to be of peculiar significance.³⁶

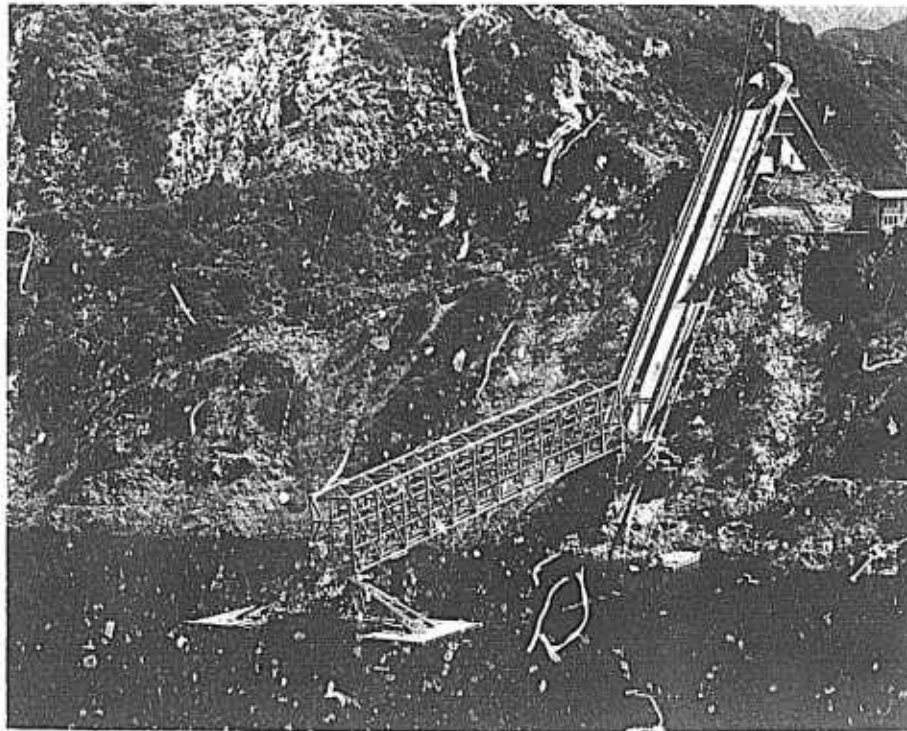
The single word "lithium" mentioned by Saylor had a significant connotation at NOTS during the first three years of Phase II torpedo development; it described a revolutionary new propulsion system—a jet propulsion system—powered by a propellant combination of lithium and free water. Like aircraft, the new torpedoes were to be powered by jet power!

According to the earlier NOTS studies, speeds up to 120 knots were entirely feasible using the propulsion with water-reactive fuels. Also, fuel economy of the lithium system was ascertained in later

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1947. But while there was never doubt as to the validity of water-reactive propellants for torpedoes, it became increasingly clear that lithium was not the best. It reacted so violently and unpredictably that it was realized that considerable research was necessary with combustion chambers and other components before a complete system would be operational. However, the first significant steps had been taken.

Long before NCTS engineers considered the potentially devastating water impact imposed by the launch of the Bureau of Ordnance's "dream" torpedo from a height of 10,000 feet at 600 knots, they were aware of CalTech's original problem of torpedo breakup even from a launch altitude of a mere 15 feet. The fixed-angle launcher (FAL) at Morris Dam had helped solve that particular problem, and just before the war ended, plans had been drawn up for a refinement of this useful development tool. It was designated the variable-angle launcher (VAL) and was specifically designed to further explore the effects of torpedo water entry.



The variable-angle launcher at Morris Dam, Pasadena, California.

Budget limitations following the end of hostilities put construction of the VAL "on the back burner" for many months. Eventually the Bureau of Ordnance realized the pressing need for the facility and construction was resumed.

The VAL facility was unique and, in many respects, quite remarkable. While its intended purpose could be simply stated, "[a facility] to simulate aerial launching of torpedoes at controllable velocities up to 100 feet per second at any angle between 0 and 40°,"³⁷ its realization was rather more complex.

For a start, there were problems with the site itself. Although extensive surveys of reservoirs and dams all over Southern California by CalTech showed Morris Dam to be the optimum site, the peninsula in the lake was badly fractured from earthquake faulting. James H. Jennison, principal NOTS engineer for the VAL project, recalled that 40,000 sacks of cement were necessary "to cement together all those loose rocks."³⁸ This was done through diamond drill holes that went deep into the rock—sometimes as far as 150 feet.

The principal feature of the VAL was to be a 300-foot-long all-welded steel launching bridge that housed a full-length launching tube 22.5 inches in diameter. Test torpedoes would be launched down this tube into the water, propelled by compressed air from a 500-cubic-foot tank. The variable angle of water entry was to be accomplished by pivoting one end of the launching bridge on a crosspiece connecting two floating barges (each displacing a thousand tons of water). A counterweight car attached to the other end of the bridge moved the bridge up or down an inclined concrete ramp.

The initial cost estimates for the VAL came close to two million dollars, but this was trimmed down to equal the amount of unexpended construction funds remaining in an old General Tire and Rubber Company contract—one million dollars. GT&R was accordingly directed by the Bureau of Ordnance to expend these funds and let subcontracts with other companies for construction of the VAL. One of these (United Concrete Pipe Company, a successful wartime builder of ships) was to fabricate all the steel structures.

The launcher designers and builders considered themselves fortunate in that fully half of their structural steel needs were provided, at no charge, by the Columbia Steel Company. The resident naval officer at Columbia, responsible for disposal of war surplus material, had kindly first approached his counterpart at the NOTS Pasadena Annex. Although the VAL was still in the design stage at

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the time, the offer was promptly taken up. Jennison recalled that the decision to accept the steel was the right one "because, a few months later . . . steel was in such a short supply that we actually cut up steel plates and welded strips together to make some sections we needed and couldn't buy."³⁹

During construction of the VAL, the constraints of time, tight budget, and shortages of materials were keenly felt, but these were to be expected in most military construction projects during the immediate postwar period. NOTS engineers worked hard to stay within the constraints, and often exhibited a remarkable degree of ingenuity. For example, the 600-ton counterweight car, described as being "much like a railroad gondola car," was first designed to be constructed entirely of steel and filled with pig iron. Jennison undertook to redesign the car, using concrete as a major construction material. Since the time for letting contracts was rapidly approaching, he set up his living room as a drafting office and worked at home in the evenings. As he later put it, "We went out with both designs competitively and got bids. The concrete car was \$20,000 cheaper and we built it that way."⁴⁰ Notwithstanding numerous battles with deadlines and dollars, the VAL took some thirty months to build at a total cost that came close to the very first estimate—two million dollars.

It was money and effort well-spent. NOTS had the best available facility for research and advanced development of air-launched torpedoes in particular and underwater missiles in general. Into this latter category came Weapon A, called by some "the flying milk bottle," understandably, because it resembled one.

Weapon A was designed to meet a long recognized need for a method of firing depth charges against a submarine within a reasonable range from a ship. Its 12.75-inch warhead contained 250 pounds of high explosive, and a rocket motor capable of propelling it to a maximum range of 800 yards. A notable feature of the weapon was that the casing for its warhead was made of plastic, used because the fuzing mechanism required essentially nonmagnetic construction throughout. The Naval Ordnance Laboratory, White Oak, Maryland, was responsible for developing the magnetic influence fuze. Remarkably, this plastic warhead could withstand underwater pressures down to a depth of 1,000 feet. As many as 22 rounds could be fired from a turret on the deck of a destroyer without reloading.

There were several logical reasons why the Bureau of Ordnance selected NOTS, with its combined facilities at Inyokern and Pasadena, for Weapon A work. Not the least of these was the fact that the

Station had the expertise in both rocketry and underwater ordnance and some unique facilities for such a development program.

Regarding the facilities for such an endeavor as Weapon A, NOTS was indeed well endowed. In addition to a rocket-propellant pilot plant at China Lake, the Station boasted a wide assortment of test facilities and ranges, including a test track whereon the crosswind launching conditions experienced by a destroyer at full speed on the high seas could be simulated.

Development work on Weapon A began at NOTS in mid-1946 and lasted for some three and a half years. While the ultimate story of this interesting weapon extends beyond the scope of this volume, it is appropriate to briefly note its future success. After introduction in 1951, Weapon A remained in the Fleet weapon inventory for eighteen years when it was replaced by another NOTS product—the ASROC (antisubmarine rocket).



Weapon A.

THOMPSON ASSESSES THE PROGRAMS

On December 14, 1947, Thompson forwarded a lengthy letter to the Bureau of Ordnance that was essentially a "state-of-the-union" synopsis of the Station's entire research and development effort. It is a significant document as it assesses the postwar programs in the context of their major problems. Moreover, Thompson went beyond just reporting current status by indicating direction of progress in the future.

For the purposes of this history, it is appropriate that we use Thompson's own words in large part to show his assessment of the postwar accomplishments of NOTS.⁴¹ He began the report by stating that

... the zones of work at NOTS are principally concerned with aircraft fire control, rockets and propellants, guided missiles, underwater ordnance (including research in the mechanics of water entry), and aerodynamic and evaluation research. . . .

Regarding aircraft fire control, he wrote:

A great deal of work is in progress on air-to-ground fire control systems, and some of these are of considerable promise. However, a major emphasis has been placed on applications involving short ranges. It appears doubtful that the ranges of future air-to-ground combat will be in the zones in which this equipment would be considered effective. It seems, therefore, that there is a need now to emphasize programs of *applied research* [emphasis in original] from which fundamental improvements can be hoped for in this field. The equipment that comes from this work should be competent to handle air-to-ground firing at much longer ranges. In solving these problems, it will be necessary to develop systems which provide compensation for relative wind, variation of angle of attack and skid. The prospective development of ground-to-air missiles which will be effective at quite long ranges, and the prospective performance of ground-to-air fire control, make it imperative, we believe, that the air-to-ground fire control systems be improved radically. . . .

Interestingly, Thompson did not mention one of the most exciting aspects of fire control development—Bill McLean's extension of the conventional concept of fire control into that of guided missiles. However, in view of the cognizance issue and because the report was intended to give the Bureau of Ordnance a summary of its funded projects, the exclusion is understandable. Thompson was not one to "rock the boat."

Predictably, a lot was said in the report about the Station's rocket programs, which Thompson categorized as short-term programs for the Navy's current needs and long-term programs for future applications. About the former he wrote:

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The present rocket program...has as its present emphasis the adaption of one or more of three types of rockets for air-to-air use and the improvement of rockets for air-to-ground use. The three types which now appear to be available choices for air-to-air work in planes traveling at current high speeds are

- (a) The low-velocity spinner (about 5 inches diameter, equipped with proximity fuze)
- (b) The small (high-velocity) fin-stabilized rocket, equipped with contact fuze
- (c) A larger fin-stabilized rocket having considerably higher velocity than the spinner (also equipped with the proximity fuze).

Apparently, the earlier problems with spinners had been solved satisfactorily as Thompson stated that "the spin-stabilized rocket in its present form is now practically finished [and] could be put into production in a fairly short time." However, the report indicated that low velocity still represented a chief disadvantage of spinners. Thompson endorsed the enthusiasm of the Bureau of Ordnance for folding-fin rockets as an alternative and went on to say that "we are pushing the development of folding fin assemblies very hard..."

The NOTS Technical Director concluded his assessment of the current program by commenting briefly on the status of the high performance air/ground rocket (and its air/water variants) as "going ahead through the study of a combination of available units." He similarly reported the Weapon A program as being "well along."

An assessment of "Guided missile projects" in the report placed a definite emphasis on future work rather than on the current programs at NOTS. Although Bumblebee and Lark were reported as "major programs...[involving] an extensive set of facilities for operation and for the assessment analysis of test results," Thompson quickly turned the spotlight on the Station's own budding development programs by stating that "NOTS is now working on the development of an air-to-air missile."

If a single conclusion can be drawn from Thompson's assessment of the weapons development programs, it might be this: despite the administrative turmoil of the first two years of peacetime operation, NOTS was productive and healthy. Also, contrary to the fears of some, was the significant fact that the fundamental concept upon which the Station was founded had not been lost or eroded.

While there was no doubt at the end of 1947 that NOTS was truly accomplishing the "development and testing of weapons," Thompson and others at NOTS recognized that the research aspect of the mission had not yet fully been realized—especially, fundamental research. On that subject, Thompson wrote:

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It is considered of great importance that a certain amount of fundamental research which offers promise of support for development programs of the future, be sponsored at this station. The proportion of time devoted by the station to this work would be necessarily only a small fraction of the total effort. On the other hand, the benefits to be derived from close association with work of this kind are very great from the standpoint of the stimulation of the applied research and development programs. It is believed that the present emphasis, as measured by the ONR support of contemplated programs in the physics of the upper atmosphere, in micro-time physics, in some aspects of the ballistics program, and in the fundamental chemistry and physics of potential components for fuel and warhead systems, provides a nearly optimum effort for this station.

Thompson's acknowledgment that applied research was being well supported by the Bureau did not diminish his feeling, shared by many scientists at Inyokern, that much more support was necessary. As he put it:

Our own views on a well-balanced program are that we must carry on concurrently all phases of a development and research program; that we cannot afford to wait for the results of applied research before engaging in primary development programs; that the whole cycle should be regarded as a continuous one with proper balance all along the line.⁴²

THE SALT WELLS PROGRAM

In the summary program report of December 1947, there was no mention whatever of any activities at the NOTS Salt Wells Pilot Plant. However, omitting this subject was standard practice as reports of such activities were specifically enjoined by the Manhattan Project. And even if a mention could have been made, it would have been stamped "SECRET, Restricted Data (Atomic Energy Act 1946), Specific Restricted Data Clearance Required."

But if a report on the Salt Wells Pilot Plant had been made at the end of 1947, it would have shown that the program at this unusual facility was vigorous, well-staffed, well-funded, and enjoyed an unmatched level of high priority.

There were problems of course; chiefly of the same type that beset the parent Station in the transitional years; for example, the civil service classification anomalies and the difficulty in coaxing the CalTech employees, many with unique specialties, to accept federal employment.

An action by Dr. Bruce Sage greatly helped the civil service transfer problem and many others in the bargain. On August 6, 1945, the same day that the first atom bomb was dropped on Hiroshima, he had written to Captain Burroughs that in his opinion the China

Lake and Salt Wells Pilot Plants should be operated as a single administrative unit. Sage had a likely candidate in mind for the job of running the two pilot plants as "a single administrative unit"; there really was only one—himself. And so it came about; the original feudal barony (China Lake Pilot Plant) was augmented by another (Salt Wells Pilot Plant), and Sage reigned supreme. Quite obviously the arrangement had the full blessing of the Manhattan Project and the Bureau of Ordnance.

The decision to integrate the two pilot plants under administrative control of the man who had essentially been their master architect was a wise one. In Sage, supported by several of his key CalTech staff who chose to join him, the Navy had a manager of proven capability. The Manhattan Project, too, was satisfied that the technical control was the best available. And the Manhattan Project opinion was quite important, as they were the prime customer for the Salt Wells product; they were also paying the bills for the pilot plant and its operations.

The end of the war brought no surcease in the tempo of these operations at Salt Wells. Rather, those who had struggled against inconceivable circumstances to beat an arduous deadline found that they were still required to "turn night into day." The first explosive blocks that had been melted, mixed, and poured at the new plant on July 25, 1945, while representing a pioneer achievement, in no way reflected the full potential of a sophisticated production line for the atom bomb components—a goal still to be reached.

First, the pilot plant itself had to be completed. During the wartime rush to get into operation, priorities had been given to only the bare essential facilities—a minimum number of buildings for melting, casting, mold cleaning, machining, and radiography; a laboratory; and a boiler plant. If the demanded monthly production was to be met, four more machining buildings originally planned, but set aside by other priorities, would be needed, as well as the advance-type magazines, change houses, and access roads required to support the operation. Also, more homes and community support would be necessary for an enlarged work force.

In January 1946 construction of Salt Wells was finally completed according to the original plan, despite delays due to renegotiation of existing CalTech subcontracts for equipment designs and procurement. By May 1946 equipment was installed, and Salt Wells was ready to go full speed ahead.

Initially, however, the sailing was far from smooth. There was an

unacceptable number of rejects due to cracking of the explosive blocks. The difficulties stemmed in part from the fact that the casting technique developed at Los Alamos could not be transferred to other facilities without modification to accommodate the design differences of another plant. Captain Joseph T. Ware, USA, Manhattan Project Liaison Officer at NOTS, later wrote, "The difficulties in transferring the technique to a plant of fundamentally different size were, mildly speaking, tremendous."

The complexities of producing the high-explosive blocks to very close dimensional and chemical tolerances had been underestimated. For many months the Salt Wells staff of engineers somewhat reluctantly had to admit the fabrication of acceptable blocks was as much an art as a demonstrable, reproducible technique.⁴³

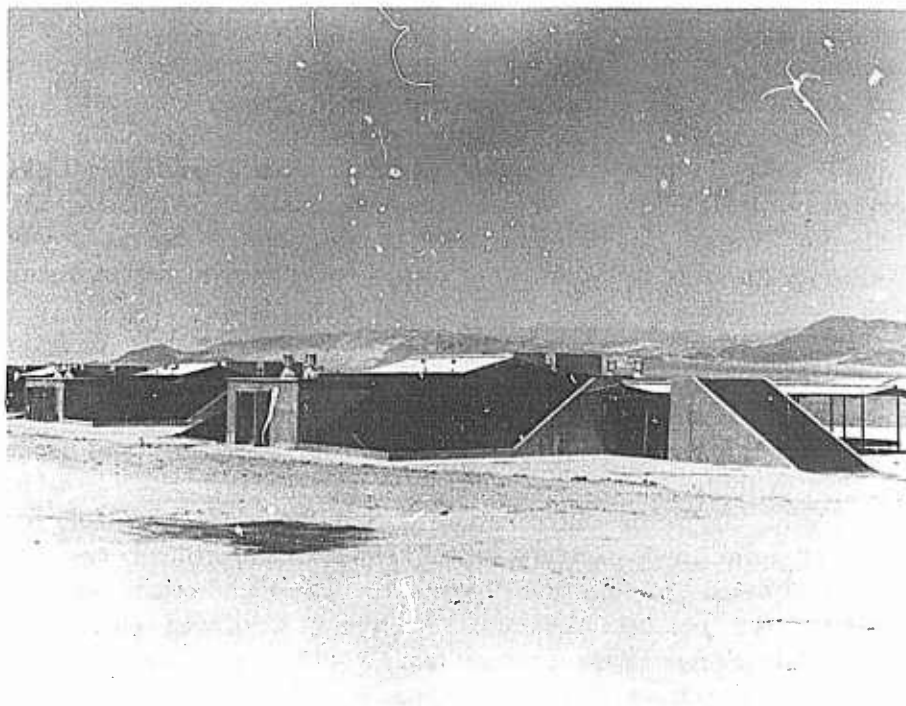
For example, one set of blocks for a spherical unit contained only a single type of explosive, Composition B. Another set of blocks in the unit had two explosive components, each with quite different propagation velocities. Yet all of the blocks required the most exacting uniformity of composition and exceedingly tight dimensional tolerances. For materials behaving much like plastics, this represented a considerable challenge.

The moment of truth would come in the final test—a proof test involving the actual detonation of a batch sample. To be acceptable, the emergent wave from the entire face of a detonating block had to be measured in fractions of a microsecond. Such instrumentation did not exist until CalTech's master problem solver, Dr. Bowen, had devised a reliable instrument that expanded the detonation flash into significant and measurable lengths on a timed piece of film. The year 1946 was notable for the solution of this and a host of similar problems that at first stood in the way of peak output for the pilot plant.

Also, 1946 was the year in which legislation was passed to form the U.S. Atomic Energy Commission that, among other things, replaced the Manhattan Project. It also formally established the Los Alamos Scientific Laboratory. This reorganization implied a formidable change of policies, regulations, and managers, and a strong effort on the part of Salt Wells to accommodate these changes at the operating level. However, the most important change (in the fall of 1946) to have an impact on Salt Wells and NOTS was the high-level decision to step up the production of atomic weapons and their components.

Almost immediately the pilot plant was operating on a 48-hour work week, with occasional 51- and 54-hour weeks for critical

operations.⁴⁴ But longer hours were not the answer; more production facilities were needed, and more people to work them.



Permanent structures of Salt Wells Pilot Plant, August 1946.

At this point, the problems of Salt Wells began to impinge heavily upon the parent Station, NOTS. Additional employees required housing and community support services, and these commodities were already in critical short supply at Inyokern in early 1947. To help offset the dilemma, the Atomic Energy Commission funded 380 sets of family quarters, a seven-room school addition (named Groves School), and extra commissary space, as well as utilities including power, water, sewage, and streets. The cost of the community additions was \$3,252,000.⁴⁵

Actually, the Commission had no options other than the original facility at Los Alamos. Salt Wells was a single source for high-explosive components of the fission-type bomb; no other such facility had been built anywhere. Therefore, if additional output was a prime necessity, the quickest and the cheapest solution was to add

whatever facilities were required at NOTS, community as well as production.

The additional facilities were completed in late 1947, and during the following year Salt Wells had increased its output to three times that of 1946. Shipment of the product, initially by rail, was problematical at first because of an extraordinarily high security classification and the constant need for armed guards. Eventually the Air Force established an air transport service from Fairfield-Suisun Air Force Base (now Travis AFB), California. This service—Fairfield/Inyokern/Albuquerque, locally designated the “milk-run”—proved to be remarkably steady and reliable as it was conducted for over five years with only 19 members of the transport team.⁴⁶

But there was new handwriting on the wall for Salt Wells in 1948, although perhaps not perceived locally. Notwithstanding an efficient plant and expert staff and an acceptable product being shipped in significant quantity, the career of the desert pilot plant was seen as finite.

Clearly, the single-source nature of Salt Wells was untenable for the long term, and planners in the Defense Department and the Atomic Energy Commission began to consider other sources. Moreover, the product itself was undergoing significant changes in design and configuration; changes that would require new tooling, equipment, procedures, and perhaps, even new major structures.

Captain (later Vice Admiral) Edwin B. Hooper, who was with the Division of Military Applications, Atomic Energy Commission, from 1946 to 1949, later summarized the pilot plant status as follows:

By the time I left the Atomic Energy Commission in the summer of '49 it was clear that the days of the Salt Wells Pilot Plant were numbered. In other words, the number of weapons . . . to be produced was such that one needed larger facilities. You could design them as efficient production facilities and didn't need to put [them] out on the desert. The decision was made, and I think too, a sensible one, to build the major production facilities elsewhere; it could be done at less cost. Whereas Inyokern was an ideal location, and had great talents to do some kinds of things, when you made a production plant this was not the best location.⁴⁷

From the time the decision was made “to build the major production facilities elsewhere,” Salt Wells continued to support the nation's program for nuclear deterrent until 1954. While the story of the remaining years of operation of the pilot plant—and its ultimate further career as a research adjunct of NOTS—is historically interesting and important, it appropriately belongs in a later volume of this published series.

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CARD Collection of Archival and Reference Documents at the Naval Weapons Center
FRCB Naval Weapons Center records stored at Federal Records Center, Bell, California
LTET Papers of L. T. E. Thompson, Scarsdale, New York

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NOTS: Flag Command

Despite its remote and isolated location, the Naval Ordnance Test Station was far from being "out of sight, out of mind." On the contrary, the Navy's activities in the Mojave Desert were watched with interest.

Other branches of the armed services, government agencies, defense industries, and the scientific community were intrigued by what had become known as "the Inyokern Operation"—the technical and scientific programs, a new look into military-civilian relationships, and an unusual community that was flourishing as an integral part of the Station. In all of these it was correctly sensed that the experimental formula for advancing science for military needs was working, and working well.

The Station had come a long way in four years; many aspects had dramatically changed. One of these changes was almost symbolic: in November 1947 a blue flag with two stars now flew over the Administration Building.

A NEW STYLE OF MANAGEMENT

Before he assumed command of NOTS on 5 November 1947, Rear Admiral Wendell G. Switzer had been Chief of Staff to Commander of Air Forces, Pacific Fleet; his duty station was Ford Island in Pearl Harbor. One can only imagine the impact of the geographical contrast between Hawaii and the Mojave Desert on the

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Rear Admiral Wendell G. Switzer, NOTS Commander, 1947 to 1949.

new Commanding Officer,* his wife and their 15-year-old daughter. The Admiral's sons were not with him. The elder son, John I. Switzer, had graduated from the U.S. Naval Academy in the class of '47 and was serving on board the U.S.S. *Hanson*. Seventeen-year-old Wendell Switzer, Jr., was at school in Virginia.†

From 1942 to 1943 Switzer commanded the seaplane tender, U.S.S. *Tangier*, in the Solomon Islands campaign, and in 1944 he participated in the battle of the Atlantic, serving as Commanding Officer of the escort carrier, U.S.S. *Tripoli*. During the last year of the war his duties took him into operation against the Japanese homeland. On this tour of duty as Commanding Officer of the fast carrier, U.S.S. *Wasp*, he was awarded the Combat Legion of Merit.¹

"Wendy" Switzer perpetuated many aspects of the personal qualification precedent set by the two former Commanding Officers of NOTS: U.S. Naval Academy, naval aviator, and ordnance postgraduate. Additionally, his many tours of duty with the Bureau of Ordnance ably qualified him as a charter member of the exclusive coterie of naval officers who had helped bring the desert Station into being. His Academy classmates of 1921 had included K. H. Noble, D. V. Gallery, J. A. Snackenberg, and F. I. Entwistle, all notables in naval ordnance. His career path had crossed that of Burroughs more than once. And in coming to NOTS, Switzer was following Sykes for the third time in their respective careers.

Switzer and Dr. Thompson had known each other since the prewar Dahlgren days. Now, as Commander and Technical Director, respectively, they worked harmoniously to constitute a close team relationship at the top echelon of the Station's command.

Although the respective personalities of Burroughs and Sykes are clearly discernible in the records they left behind them, the same cannot be said for Switzer. His was a more subtle management style characterized by a calmness in his approach to problems and a high degree of smooth diplomacy. But if accomplishment is a measure of leadership, it soon became apparent that NOTS had acquired a particularly effective brand of leadership at the helm. Moreover, Switzer was liked and respected by civilian and military alike. One of the Station's senior scientists later recalled:

* During Switzer's tenure at NOTS the title of the position was changed from Commanding Officer to Commander.

† Each of Switzer's sons was destined to become a naval aviator like his father. However, in what must be an exceptionally profound family tragedy, both boys were subsequently killed in flying accidents in 1955, less than two months apart.

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I think if he wanted to accomplish something, he would do it in such a nice and delicate way that he would accomplish what he wanted and nobody would even realize it.²

A similar point of view is expanded in the recollections of a naval officer:

Let me say he understood the problems of this place. He was not a technical man, but Wendy was a very thorough person. But he would listen to all sides of a case. He wasn't on that went off half-cocked. . . . And so he was a very human person.³

Switzer's personal traits undoubtedly contributed largely to his success at NOTS, and his apparent proclivity for a behind-the-scenes operating philosophy in no way diminished the fact that NOTS flourished in a very real sense under the aegis of his command. It is a matter of record that he attended only four of the 47 meetings of the Research Board during 1948. Yet, that year was particularly notable because the NOTS technical programs started to gather dramatic impetus toward an across-the-board involvement in rockets, missiles, fuzes, fire control, and torpedoes. Other achievements wrought under Switzer's leadership included a meaningful refinement of the Station's organizational structure and the activation of a brand-new multimillion-dollar research laboratory. And, most important, by not adding fuel to old fires, he made it possible for the community to come together again as a cohesive whole.

But the reasons for Switzer's success extended beyond those of being "a very human person," and a key to these is discerned in the same previously cited recollections—namely, "he understood the problems of this place."⁴

Also, Switzer had been well briefed by people whose judgment he valued highly. One of these was the former Experimental Officer, "Chick" Hayward, who aside from being a warm personal friend, was also related by marriage. Hayward later recalled the circumstances of the briefing:

I talked at great length with him [Switzer] and "Deak" Parsons did before, when I knew he was coming to take Sykes' place. And I told him—I gave him the whole "ball-of-wax." And Wendy knew the argument had been closely associated with the [scientific community]—and what was going on in Washington and the Research and Development Board; all of the problems. He came out with the intention as he said, "Well, I want a solution, I don't want to become the problem." And . . . he was an admiral and had stature, and could get right into the top all the time . . . he had the prestige that he could do this.⁵

Many agree with Hayward that Switzer's flag rank was a strong and vital factor in his achievement of an effective command. A former department head at NOTS offered a typical endorsement of this viewpoint:

The Commander could go back to the Bureau of Ordnance with a lot more "clout" than had been previously the case. And Switzer did a lot for the Station in using that clout in the East...to me, this looks like personnel planning, skillfully done. You get the Station grown, you get it made into something that's got some procedures and regulations, and then you nail it down with a guy that's got some clout in Washington.⁶

In contrast, Vice Admiral Frederick L. Ashworth, who formerly commanded NOTS as a captain, did not agree that having an admiral at the helm offered an advantage.

I'm inclined to say that you probably have better luck dealing with the Bureau as a captain than you would as a flag officer. I just don't know, I have a feeling you might be able to deal on a more direct and cooperative basis with the guys that you had to deal with in the Bureau on a man-to-man kind of a level probably in a more effective fashion than if you were dealing with the same guy and you were a flag officer and he was a captain and he was essentially saying, "Aye, aye, sir," to everything. I'm not sure that maybe in the long run you wouldn't get a better result by the more or less equal confrontation and letting things stand on their own virtue and not be forced through by the fact of a superior rank guy saying, "Look, this is the way I want it done," and the other guy saying, "Yes, sir."⁷

In all probability, the prestige of a flag station was felt more keenly by the people who lived and worked at NOTS. To them, the survival of the "desert experiment" was doubly important in the face of two turbulent years, replete with a host of problems experienced firsthand at the living and working level. It was as though the efforts of all in coping with these problems had been somehow recognized and rewarded; the blue flag with two stars must have had the same significance as a wartime "E" pennant.

The older hands at NOTS did not delude themselves into thinking that there would be no more problems. On the contrary, some of the old problems were still around that affected both home and job. Housing and civil service classifications continued to be areas of principal concern. Housing was still too often identified with not even having a home in the first place, and solutions regarding civil service classifications were all too slow in coming.

Ironically, one of the first problems looked at by the new Commander had neither the epic stature of the housing dilemma nor the pervasive quality of the job classification struggle. This centered around what the Navy's newest ordnance installation in the Mojave Desert ought to be more properly, and appropriately, designated.

"WHAT'S IN A NAME?"

The NOTS name is a story in itself. Beginning with Captain Burroughs, practically each successive NOTS Commanding Officer (or

Commander) made a personal bid to have the name changed; everyone was unsuccessful. Behind the story are major themes: rivalry between powerful Navy bureaus, and also between the Navy and its sister services; and challenges and counterchallenges concerning leadership in major weapon development programs.

One of the earliest discussions about a name for the Station occurred in the brief period between the acquisition of the land and the official establishing date of NOTS in November 1943. It took place in a telephone call between Captain (later Admiral) James S. Russell, who headed the Aviation Ordnance "Desk" at the Bureau of Aeronautics, and Commander Jack Renard, whom we have already met as Mitscher's "man on the job" for rocket development on the West Coast.

In a later interview, Renard recalled the essence of the conversation:

After we had acquired this land . . . I got a call from Jim Russell, and he said, "Hey, we got to call this something you've got out there." And he said, "What do you think? How do you like Naval Aviation Ordnance Test Center?" I said, "It sounds marvelous." He said, "We've got to call it something; we can't call it--'Hey, you guys out there'--we've got to name you so when we write you a letter we know who the heck we are talking to, in what area we are talking, a name for what you are doing." Well, that didn't last long because the Bureau of Ordnance took a dim view of calling it *aviation* Test Center.⁸

Clearly, the Bureau of Ordnance had no intention of changing the brand it had put on Inyokern. There were subsequent bids to have the word "aviation" added to the Station's name, most notably by Burroughs, but their lack of success only seems to emphasize that the original brand of ownership was deeply seared into Inyokern's hide. It was, as Admiral Kitts subsequently proclaimed, "an *ordnance* test station" and to the Bureau of Ordnance, the exclusion of the word "aviation" from the name would preserve its status. After the war there was more justification to keep "aviation" out of the Station's name: much of the work on board was not associated with aircraft weaponry (e.g., ship-launched torpedoes and Weapon A).

At the beginning nobody apparently saw any inconsistency in naming a station "Naval Ordnance Test Station" and then proclaiming its mission to be research, development, and test. The reason has been explored in an earlier chapter: in essence, for the first two years of its existence, testing of CalTech's weapons was the Station's principal function.

To many it was a matter of semantics. A proving ground automatically implied a certain amount of applied research and

development work. Burroughs was one who felt this way, recalling, no doubt, the way it had been at the Naval Proving Ground, Dahlgren. Burroughs had another defense for the use of the term "Test Station":

... there's a little cover in this name. [It] gave a little screen on what was going on, as far as people on the outside reading this. We were just firing "stuff" out here—just banging them out. Somebody else does the work—we bang them out.⁹

In the same vein, Burroughs added that "there was no sense in advertising this [NOTS] as the world's greatest research and development place."¹⁰

At the war's end a considerable reputation had been acquired by NOTS for its testing prowess. Unfortunately, good reputations, like bad ones, are hard to live down. The reputation of NOTS served to strengthen the bond between name and mission. Thus the transition from a purely testing function to fulfilling the destiny of a primary research and development center was a slow, frustrating process in the immediate peacetime years.

In the postwar period there were people in Washington saying, "That is a test station; look at the name." This connotation had little effect on development work, but it did have a negative effect on other forms of research and development. As has been shown, the Station's role in a vital new weaponry field, guided missiles, hung in the balance, and the concept of NOTS as a test station was on the wrong side of the scale.

Despite the fact that NOTS had no association with the small desert town of Inyokern by 1948, the Station continued to be known as NOTS Inyokern. While the original nucleus of NOTS had been at Inyokern's Harvey Field during the war, the focal point of the Station's air activity had positively shifted to China Lake with the commissioning of Armitage Field. Now the old Inyokern airfield had been stripped and given back to Kern County. Similarly, the community of Inyokern had reverted once more to a size that fitted its own new description, "a nice little desert town." Conversely, the relatively large Navy town of China Lake some 10 miles away from Inyokern now boasted a population of 10,000 souls and was the largest community in the whole of the northern Mojave Desert.

Burroughs might have foreseen this growth back in April 1944 when he petitioned the Bureau of Ordnance to have the (then) budding community officially named "Lauritsen, California." But Hussey did not agree. As he put it, "The Chief of the Bureau . . . feels that a name more intimately related to the Navy and naval history is to be preferred."¹¹

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Some felt that the Station might somehow be locked into the official post office designation. Accordingly, in August 1945 Lieutenant Commander Vossler recommended to his new Commanding Officer, Captain Sykes:

Change the post office address of the station as soon as possible. "Inyokern" is a queer name at best. Most Naval personnel associate it with "Indio" and cross it off their list. Most potential Civil Service personnel think it sounds silly. Anything would be better, such as "NOTS-Indian Wells Valley, California", or "NOTS-China Lake, California", or "NOTS-Ridgecrest, California". It is only the matter of establishing a new post office which would certainly be warranted.¹²

In the beginning (December 1943), the United States Post Office decreed that the Navy-operated branch of the post office at Mojave, a small railroad town some 60 miles south of NOTS, should handle the Station's mail; this undoubtedly because Mojave happened to be the location of the U.S. Marine Air Station. Burroughs successfully fought this decree, but did not win until after a massive volume of Station envelopes and letterheads had been printed for "NOTS, Mojave." However, instead of the NOTS mail being processed through the inconveniently located Mojave post office, it was now handled by the fourth-class post office at Inyokern, located in the general store operated by Clarence Ives, who also was the postmaster. The tiny village post office at Inyokern continued to serve NOTS for nearly four years.

In the meantime NOTS headquarters had geographically been relocated, and pressures to get an independent post office for the China Lake community mounted. In December 1947 shortly after he took command, Admiral Switzer wrote to the Chief of the Bureau of Ordnance pointing out that "informal advice had been received that an independent, second-class post office will be established on station property on or about 16 January 1947 [should read 1948]. This post office will be named 'China Lake'." He went on to recommend that the Station be redesignated "the Naval Ordnance Test Station, China Lake, California."¹³

Switzer's ploy to use the name of the new post office as the thin edge of the wedge to get the Station name changed was as unsuccessful as the efforts of others had been. His "clout back East" was no match for the greater clout of Admiral Noble. As far as Noble and other Bureau of Ordnance officers were concerned, Inyokern was Inyokern just as a "rose is a rose." Noble responded to Switzer's recommendations with a terse letter whose essential brevity underscored the Bureau's rocklike intransigence:

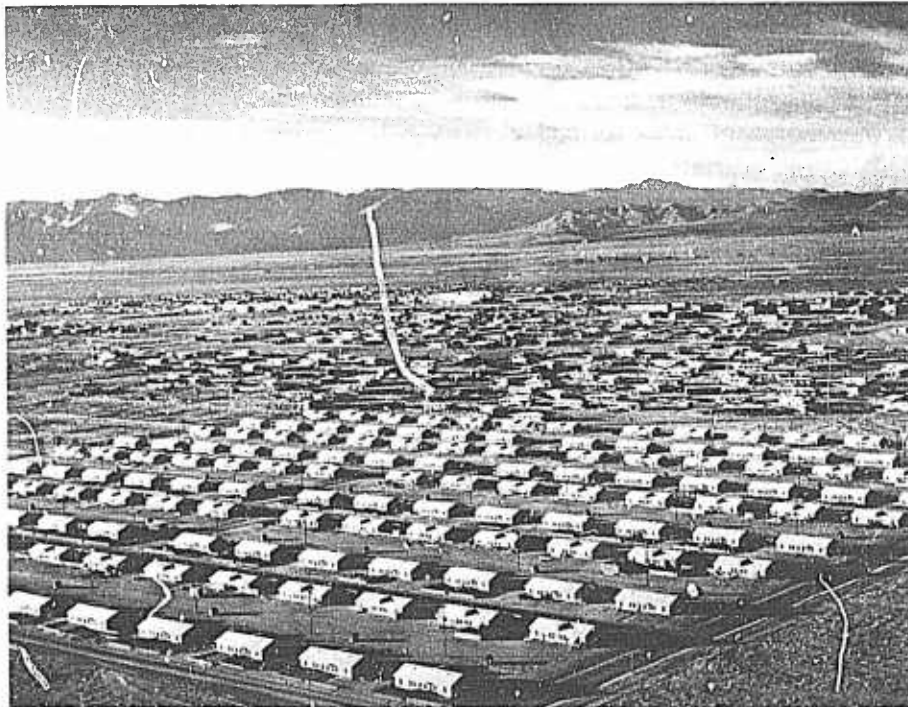
NOTS: FLAG COMMAND

1. The Chief of the Bureau of Ordnance desires that the name "Naval Ordnance Test Station, Inyokern, California" be retained without change.
2. The post office name "China Lake" is acceptable to the Bureau.

A. G. Noble¹⁴

And so it would remain "NOTS Inyokern." For another seven years visitors to the Station arriving by road would continue to be initially bewildered, and the residents of Inyokern would still be compelled to give directions as to the actual whereabouts of NOTS. At the same time, these patient citizens would be required to furnish an explanation—*ad nauseam*—as to the name anomaly. This would go on until 1955 when the Secretary of the Navy officially changed "U.S. Naval Ordnance Test Station, Inyokern, California" to "U.S. Naval Ordnance Test Station, China Lake, California."¹⁵

But on the whole, the problem of the name remained at a superficial level; if it could not be changed, that was the way it would have to be. Ironically, on February 16, 1948, the name "Inyokern" became even more irrevocably bound to NOTS, and at



Courtesy Life Magazine

NOTS and its community, February 1948.

the same time acquired national recognition. On this date, the feature article of *Life* magazine was entitled "Rocket Town." The edition's center-spread photograph taken from an aerial vantage point showed the housing and business center of China Lake, NOTS headquarters, and the nearly completed Michelson Laboratory. The caption began, "In a desert basin sheltered by the high Sierras, the *town of Inyokern* [author's italics] spreads out in an orderly array . . ."16

Perhaps a clue to the tenacious retention of the Station's name exists in this comment by highly placed officers, "What does it matter what the Station is called as long as it is understood what the Station does?" The trouble was that this understanding was often considerably less than universal.

ACQUIRING LABORATORY STATUS

By late 1947 NOTS was growing ever closer to fulfilling the original concept of an integrated research, development, and test center. Moreover, the function of research strongly implied a role as a Navy laboratory as contrasted to that of a proving ground.

Physically, in late 1947, there was much tangible evidence of *de facto* laboratory work at NOTS. Research activity and equipment that had been scattered around the Station—housed in Quonsets and makeshift temporary buildings—were being progressively centralized and relocated in more permanent structures. Principal of these was the huge, new six-wing Michelson Laboratory that was partially occupied by mid-1947, but which would not be formally dedicated until May 1948.

But somehow to many, the brick-and-mortar evidence of the NOTS laboratory role was not enough to justify the appellation "Navy laboratory," and the reasons why are worth examining as they reflect the nationwide posture regarding postwar military and scientific effort in general—and the role of Navy laboratories in particular.

If anyone could be expected to question calling the Naval Ordnance Test Station a "laboratory," it would have been the scientists and naval officers at the Naval Research Laboratory (NRL), Washington, D.C. This venerable organization held title as one of the first Navy laboratories, having been established in 1923. From the time it was established, NRL built an enviable reputation in the sciences pertinent to possible naval applications, notably in radio- and underwater-sound detection and radar, laying claim to the fact that

"American radar was conceived and born at the Naval Research Laboratory."¹⁷

The following description illustrates the tough competition facing a Johnny-come-lately contender for the title of Navy laboratory:

The laboratory [NRL] emerged from World War II in an enviable position: It was big, it was affluent, it had a preeminent reputation among government laboratories. Above all, it was riding high on a wave of unprecedented public faith in scientific research. The most technical of all wars, with its Wagnerian climax at Hiroshima-Nagasaki, had been won largely because America was able to keep a technical stride ahead of its enemies. Now Congress was willing to bear the cost of extensive military research. Thus the Naval Research Laboratory was not cut back. While ships were being placed in mothballs by the thousands, research was maintained on a near-wartime footing. New equipment was acquired almost for the asking, and manpower was limited only by the competitive market for trained scientists...¹⁸

On August 1, 1946, an event occurred that was highly significant for NRL and for Navy research. On this date an Act of Congress established the Office of Naval Research (ONR). The significance to NRL, of course, was that this new relationship assumed the sponsorship of what was essentially an office with bureau status, and funds appropriated specifically by Congress. After more than twenty years of being shuttled back and forth between the Bureaus and the control of the Secretary of the Navy, NRL had now found a permanent guardian.

The larger significance of the establishment of ONR was that it represented a giant step toward filling the void left by the dissolution of the National Defense Research Committee and the Office of Scientific Research and Development. That such a void would exist was clearly recognized by the scientists and officers concerned over long-term defense. As early as April 1944, while the war with Germany still raged, the Secretary of War and the Secretary of the Navy had jointly appointed a committee to explore the conduct of defense research in the postwar era. Chaired by Charles E. Wilson, the president of General Electric, the membership included eight high-ranking Army and Navy officers, and four civilian scientists.

While the Committee on Postwar Research was generally unanimous in its recommendation for the establishment of a permanent body to be called the Research Board for National Security (RBNS), it was sharply divided as to how the Board should be organized: as an independent federal agency (by congressional action), or as an agency under the National Academy of Sciences (by executive order). A bitter struggle ensued over an essential issue: namely, who was to control postwar defense research, military or

civilian?¹⁹ While the Board was organized under the Academy proposal in mid-February 1945, it never became effective. Exactly one year later, the Secretaries of War and Navy acted to administer the *coup de grace* to the RBNS.

During the immediate postwar years, while the nation was floundering in its attempts to formulate a policy for peacetime military research, the Navy took the initiative in respect to Navy interests by lighting its own research torch from the NDRC-OSRD embers.

A clear guideline was inherent to the founding of ONR: that it "must not take over the research and development work of the Bureaus associated with their cognizance responsibilities."²⁰ Thus, although ONR symbolized the Navy's determination to conduct its own research through contracts, grants, and its own laboratories, the Office exercised control over only a single laboratory—NRL. The individual Bureaus could freely operate their own. Two major laboratories were under the Bureau of Ordnance: NOTS and the Naval Ordnance Laboratory (NOL), White Oak, Maryland.

During the immediate postwar years, the destinies of these two installations became curiously linked even though their early histories were quite dissimilar.

Unlike the World War II genesis of NOTS, the early beginnings of NOL reached back more than two decades to 1918, the year the Bureau of Ordnance established a mine research development facility within the Naval Gun Factory at the Washington Navy Yard. This was the original nucleus of NOL, White Oak. A short time later the Experimental Ammunition Unit was established and occupied part of the same building, the Mine Building at the Naval Gun Factory.

In 1929 the Mine Unit and the Experimental Ammunition Unit were consolidated and renamed the Naval Ordnance Laboratory; its mission was broadened to cover the entire spectrum of naval ordnance.

As the war approached in 1940, the Laboratory began to expand as a high priority effort was initiated to develop countermeasures against the new German magnetic mines. By 1942, the fundamental problems of the magnetic mine and countermeasures against it were essentially solved, and the Laboratory began to work extensively in other areas such as depth charges, bombs, fuzes, and torpedo exploders. Toward the end of the war (in late 1944), NOL's personnel had grown to 1,800, and these were housed in ten buildings at the Navy Yard. This forced dispersal of personnel greatly inhibited

work coordination. Moreover, the available buildings usually lacked some of the necessary facilities and equipment. It was apparent that only relocation could solve the problems. Accordingly, late in 1944, a tract of 378 acres was purchased at White Oak for the Laboratory. Work progressed rapidly, and on August 15, 1946, the cornerstone of the main building was laid by Secretary of the Navy James Forrestal. By mid-1948 the new Laboratory was in operation, although formal dedication did not take place until January 31, 1949.

Despite the fact that NOI was in reality one of the Navy's first and therefore oldest laboratories, it was generally thought of as a new laboratory because of its relocation, brand-new facilities, and increased scope of operations. Thus, it was categorized in much the same way as was the new laboratory at Inyokern. NOTS and NOL were regarded as sister laboratories and seemed to epitomize the Bureau of Ordnance's grand geographic plan for postwar research--a major laboratory on the East Coast and one on the West Coast. At the end of the war, they were the main centers for ordnance research and development.*

Both NOL and NOTS developed Principles of Operations based on military-civilian partnership. Both enjoyed a comfortable degree of funding support by the Bureau of Ordnance, although some at NOTS concurred with Thompson's feeling that the Station was not enjoying the "ample and continuous backing for basic research"²² that characterized ONR's support of its own Naval Research Laboratory. On the other hand, applied research at NOTS was well supported, as evidenced by the fiscal year 1948 million-dollar budget for applied research.

NOTS and NOL shared many common problems, among them a Navywide tightening of travel budgets and restrictions on long-distance telephone use. In the early part of 1948, the freeze on travel and communications was still officially in effect. But strong efforts were being made at the Bureau of Ordnance level to ameliorate the situation. On March 3, 1948, Admiral Noble wrote jointly to the Technical Directors of NOTS and NOL:

* In addition to NOTS Inyokern, and NOL, Washington, D.C., the major ordnance facilities of the Bureau of Ordnance for the wartime period were Naval Proving Ground, Dahlgren, Virginia; Naval Torpedo Station, Newport, Rhode Island; Naval Powder Factory, Indian Head, Maryland; Naval Mine Depot, Yorktown, Virginia; Naval Mine Warfare Test Station, Solomons, Maryland (operated jointly by the Bureaus of Ordnance and of Ships); Bureau of Ordnance Test Unit, Dam Neck, Virginia; Explosives Investigation Laboratory, Stump Neck, Maryland; and Explosives Investigation Laboratory, Port Townsend, Washington.²¹

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...Until we are able to influence the personal views of certain very important members of the Congress, I feel that we must continue to handle travel and communications within the present limitation of funds. Through closer personal management and sympathetic treatment I am confident that the situation may be somewhat alleviated and it is my intent to emphasize this feature in attempting to achieve at least some partial relief through better administration.²³

But quite apart from showing the Bureau Chief's concern about travel and communications, Noble's joint letter also summarized the Bureau of Ordnance's philosophy for the sister laboratories:

I think that both of you are now aware that the Bureau is exerting every effort to make available material facilities of the highest quality and that some of these facilities are now in the process of becoming available at both of your stations and that further additional facilities will be made available in the future. Also the Bureau is continuing its efforts to fully outfit both stations so that the facilities available will be of the highest order of quality and adequate as to size for the fulfillment of your missions.

I am heartily in agreement with you regarding the necessity of creating and maintaining a technical staff of outstanding quality. I appreciate the difficulties which must be overcome, as well as the necessity for combating the efforts of other agencies who would recruit our best people. I will heartily support all efforts in seeking and obtaining exceptionally well-qualified people and will bitterly oppose any effort of other agencies to recruit your personnel.

For Thompson at NOTS and Ralph Bennett at NOL, the following paragraph might have conveyed a very special meaning:

Although I do not consider it necessary to do so, I wish to make it a matter of record that I, as the Chief of the Bureau of Ordnance, and also the officers and civilian personnel of the Bureau of Ordnance, fully appreciate the necessity for the establishment and maintenance of a strong, important, and virile research program; and that in their respective fields Naval Ordnance Laboratory, White Oak, and Naval Ordnance Test Station, Inyokern, are not only invaluable, but are the principal source of authoritative competence in the Navy, if not in the entire United States.

A. G. Noble²⁴

If there had hitherto been any doubts as to how NOTS and NOL were measuring up in the first postwar years, they surely must have been dispelled by this gratuitous vote of confidence by the Chief of the Bureau of Ordnance.

Admiral Noble's declared intention "to provide adequate operational funds on a continuing basis" possibly implied that he was seriously studying a proposal that had recently been made by NOTS. It concerned the important matter of funding for research that was not necessarily related to any weapon development program or task.

The action taken, and the reason for it, is clearly described in the minutes of a NOTS Research Board meeting on November 14, 1947; the item was headed, "Funds for Applied Research or Special

Equipment to be Administered at the Discretion of the Station." The item read:

Dr. Shenk will prepare a draft of a letter for the Bureau of Ordnance to be forwarded to Dr. Thompson in Washington, D.C. for discussion. This letter will make a specific proposal to the Bureau of Ordnance for funds (either a certain percentage from project orders or a special allotment of funds) which will be under complete control of the Station to be used for needed experiments in applied research, special equipment, or to fill in a gap when necessary. These funds are to be expended on requirements of the Station which have not been specifically directed by the Bureau of Ordnance.²⁵

Both Hussey and Thompson felt that such funds were absolutely necessary. Hussey, commenting in a later interview, cited an earlier precedent for providing "a five percent application of funds to basic research on contracts with the universities, which solved our problem of giving people enough elbow room to do the job on their own." The former Bureau Chief further commented that it was important because "it insures that the collateral thinking that scientists do can be brought to focus on ordnance problems . . . the work that they do in pure research keeps their hand in and sharpens their wits and their appreciation."²⁶

The NOTS application for discretionary funds was not formally approved by the Bureau of Ordnance right away. However, it appears that sometime in 1948 an informal arrangement occurred between the Bureau and the Technical Directors of NOTS and NOL whereby funded projects would include a percentage allowance for discretionary research.²⁷ At first, the fund was called "technical overhead," and represented some 3% of each Station project. Eventually, a separate budget line item was established by the Bureau that was designated "Exploratory and Foundational," or more familiarly, "E&F," and the amount was raised to 5%.

The result of available E&F money in 1948 was seen in a positive stimulation of new-approach exploratory work at NOTS and at NOL. Thompson later commented, "In my opinion, this provision meant as much as anything ever done to attract and *hold good R&D people*" [Thompson's emphasis].²⁸

RANGES: A QUESTION OF INVOLVEMENT

Anyone coming back to NOTS in early 1948 after an absence of two or more years invariably reacted, "I can't believe how much the place has grown!"

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Of course there was the obvious and tangible evidence of growth everywhere: the buildings—both administrative and technical—the ranges, the residences, and the community facilities in general. But the place had also grown up in the more important sense of maturity.

There was a sense of increased confidence discernible in the Station employees, military and civilian, and radiations of optimism that gave clues to a widespread high morale. There were still bickerings about the commissary, Public Works, and housing, but they were far softer—gentle reminders of the past period of turbulence and administrative problems.

The Station had moved from introspective concern with its own problems to broad involvement in studying and meeting the many weapon needs of the Fleet and in representing the Navy on matters of ordnance and science.

More and more distinguished visitors were coming to the desert these days to get acquainted with the grand experiment at Inyokern; not only members of the Bureau of Ordnance family, but cabinet officials and high-ranking officers in the other Department of Defense



Admiral Nimitz inspects NOTS, October 25, 1947.

agencies. Distinguished men of science were also coming to visit their fellow scientists on the Station staff, and leaders of the newly emerging aerospace industries were also visiting in increasing numbers. Sometimes the visitors arrived *en masse* to attend conferences and seminars that were being held at NOTS with ever-growing frequency. And the word started to be passed around by those who arrived by automobile that Inyokern was actually a miniscule desert hamlet some 8 miles removed from the Naval Ordnance Test Station at China Lake.

Other kinds of words were also being passed around; words to the effect that the desert scientists and engineers were unusually proficient in their fields of propellants, aerodynamics, and explosives, physics, and chemistry. And these individuals were being asked to present papers for professional societies throughout the free world. Many were requested by name to serve as consultants to industry and government agency alike; for example, Aerojet and the National Advisory Committee for Aeronautics (NACA, the forerunner of what was to become NASA).

As part of the Station's newfound maturity, a free interchange of ideas with other laboratories was nurtured. In addition to increasing involvement in research and development on a national scale, NOTS held a position of leadership in weapon testing. Throughout the postwar period it was among those in the nation's ordnance community who were asking such questions as, "What kind of ranges are needed? How many? Where? Who will use them?" These questions were first raised at the end of World War II as part of the planning of the weapons for the nation's postwar arsenal. In particular they were aimed at meeting the testing needs for short-range guided missiles and for the long- and intermediate-range ballistic missiles whose development was initially sparked by the German V-2.

In the postwar period plans were formulated for new missile ranges on the East Coast at the Banana River Air Station, Florida,* and on the West Coast at the Naval Air Missile Test Center, Point Mugu, California. But the need for instrumented ranges was immediate. Much of this need was met by the Army's new proving ground at White Sands, New Mexico, and by NOTS.

* Eventually, this test range incorporated Patrick Air Force Base and became the world-famous Atlantic Missile Range (Cape Canaveral), noted for early space-flight programs.

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By any contemporary standards, the NOTS ranges were first class with instrumentation for detailed coverage of launchings and of short- and mid-range missile trajectories unequaled elsewhere. And the Station possessed the expertise for range operations that came as part of its CalTech heritage.

The big problem for NOTS management was how to achieve a workable balance between the test support for NOTS research and development programs and the outside requests for testing, which were generally of a more routine nature. As Captain Burroughs had cautioned when the Station was first conceived, there would be dangers if proof and routine testing diluted the Station's primary work of weapon development. His postwar successors remained alert to that threat.

NOTS felt it had a specific and well-defined need for its ranges; namely, to support an overall integrated RDT&E facility, where as one scientist put it, "You could generate an idea in the laboratory and immediately take it out and see if it worked." Understandably, NOTS was not particularly anxious to open its ranges to all comers if such an involvement meant that the Station's programs might suffer. But like it or not, such involvement was imminent.

This reluctance to get involved was brief—cut short by a new *entente cordiale* that was joined by the Army and the Navy. This harmony began in October 1945 when the Army invited the Navy Department to conduct tests of Navy guided missiles and pilotless aircraft at the White Sands Proving Ground in New Mexico. The Navy's response to this invitation "expressed the appreciation of the Bureau of Ordnance and Aeronautics . . . and their concurrence with the views of the Chief of Ordnance with regard to the cooperative use of this range by Army and Navy facilities."²⁹ And the Navy in turn invited the Army Ordnance Department to make use of Navy guided missile facilities in carrying out Army projects.

And so it all began, clearly indicating NOTS involvement in the interservice use of the nation's ranges. When the Committee on Standardization of Range Facilities was established, NOTS played a major role.³⁰

There were no negative consequences of range involvement, and the Station's research and development mission was not diminished by such involvement. Rather, there were benefits. Through the "Range Committee," NOTS now had a firm channel for dialogue with all the established and newly emerging ranges and proving ground agencies in the country.

THE PROBLEM OF PRODUCTION ENGINEERING

While some involvements were sought by NOTS and others shunned, there was one that was viewed with a certain degree of ambivalence: the production of hardware.

The issue of whether NOTS should have a limited production capability was a thorny one with equally strong pros and cons. Some took the viewpoint that no *true* laboratory produced hardware; that the laboratory did the research and designed and developed the item, and then handed over the drawings to industry for mass production. Others did not concur. Thompson was one of these, and he expressed his desire for some limited or pilot production at the laboratory level:

Many good weapons systems fail because the development work and the design work haven't been done with a sufficient regard for... what it takes to produce in quantity. We know that we have to have most of our things in great quantities. If they can't be produced, then that's a serious handicap in comparison with some other weapon systems which can;... the other point... has to do with reliability of the equipment, the choices that can be made to get dependable equipment. So many times, we have equipment that works in the laboratory or just outside the laboratory, but get it out in the front lines and something goes wrong... and the operating people get discouraged and they say, "Take this stuff out; I don't want it."³¹

There were sound reasons why Thompson, and a few others, felt it mandatory to get into production engineering. One of these was a need to fall in line with a new concept in weapon development: a philosophy known as "concurrency," where the whole development cycle, from initial design to Fleet delivery, could be considerably shortened by overlapping all the steps in the development train. Thus, producibility was considered even while the item was still on the drawing board, and limited production was called for concurrently with development testing. Even after the item was delivered to the Fleet, there was provision for feedback improvements to be made in the full-scale production stage. Patently, NOTS needed to be involved with production to some degree. The question remained, to what degree?

There was at Inyokern a strong, long-established precedent for production at the China Lake and Salt Wells Pilot Plants. The proponents of a production capability for the Station cited this precedent and argued that *pilot* production of hardware was all that was necessary. In other words, fabricate enough to verify that the item can be produced satisfactorily before handing it over to private industry. Yet, even this logic was lost on the adversaries of

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production who claimed that such was not implicit in the Station's mission.

The problem, of course, went far beyond the fact that production engineering (sometimes referred to as "development engineering") was not even mentioned, let alone implied, in the original founding order (research, development, and testing of weapons). From the Bureau of Ordnance's standpoint it involved money: funding for production facilities and machines and assembly lines; billets for engineers and machinists. Also, at the Bureau level, in those days as it is now, there was a sensitivity toward any suspicion that the government was in competition with private industry.

The position of Admiral Noble, Chief of the Bureau of Ordnance, was that the Station should carry design of a new weapon no further than "general arrangements," leaving the development of production drawings to other agencies either within or outside the Navy. Schoeffel, Noble's Deputy Chief, took up the case for NOTS by advancing the thought that "there will be times when it may be necessary for Inyokern to make up complete production drawings." Having thus opened the question with the Chief, Schoeffel then encouraged talks on the subject between NOTS and Philip H. Girouard, Chief Engineer of the Bureau's Research and Development Division. A key point was whether or not the Station should develop a production engineering capability. In setting up these talks, Schoeffel also suggested what in later months was adopted as the plan; namely, that a NOTS production engineering department be set up as one of the units of the Pasadena Annex. This location was proposed so the "group may be in closer touch with the production thinking" than it would be at the isolated desert location. In attempting to open the way for production engineering at NOTS, Schoeffel was implementing his basic position in regard to NOTS as stated to Thompson:

...I wish to reiterate that I shall always attempt to see that the Bureau does not interfere with your proper prerogatives of determining the organization for and the "how" of getting things done at Inyokern.³²

It would not be until January 1949 that the Design and Production Department was added to the NOTS organization as part of the Pasadena Annex. But the eventual move was triggered by these earlier actions by Thompson and Schoeffel. In the meantime, the new laboratory complex nearing completion at NOTS Inyokern included a remarkable machine shop replete with a wide variety of machinery of



Rear Admiral Malcolm F. Schoeffel, Deputy Chief of the Bureau of Ordnance, 1947 to 1950 (later became Chief of the Bureau of Ordnance).

the latest type. The portents were clear; a limited production engineering capability was in the cards for NOTS.

THE ADVISORY BOARD

With the end of the Office of Scientific Research and Development and the severance of formal ties with CalTech, the Station lost ready access to many of the scientific and industrial leaders outside the Navy. Personal contacts on an individual basis continued to be made; for example, former OSRD leaders appear to have given advice when the Principles of Operation were under discussion. But there was no recognized formal arrangement through which the Station could seek the advice of scientific and industrial leaders.

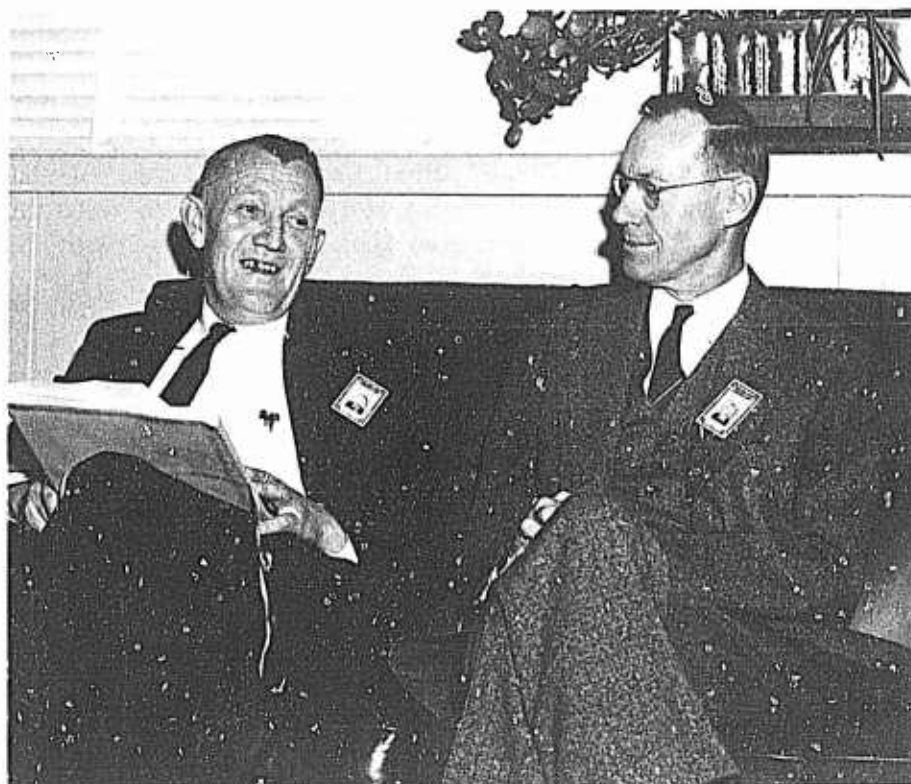
This was particularly apparent to Thompson when he sought answers to such questions as how to evaluate the efficiency of the Station, and who could honestly gauge the caliber of the technical and scientific effort and offer fresh viewpoints and guidance for improvement.

Inspection teams, of which there were many from various parts of the government, just didn't work. While these teams capably analyzed administrative operations, the teams sent out usually did not have the technical and scientific competence in the many diverse disciplines to make sound judgments. Moreover, a broad-brush inspection visit, usually for only a few days, could do little more than absorb a general level of briefing. As Thompson put it, "People who are going to appraise a program have to know something about it."³³

Others besides Thompson had been concerned about the Station's need for "sophisticated evaluation of the technical programs."³⁴ Even before Thompson came on board in 1945, a proposal was made "to establish an Advisory Committee which will be effectively available to the Research and Development Department in an advisory capacity, with particular reference to general questions of research and development objectives and to the promotion of most advantageous contacts with other institutions."³⁵

No formal action appears to have been taken at that time to establish such a committee, and the first evidence of its existence shows up in the minutes of the Research Board meeting on August 3, 1946. Buried in a long "List of Committees and Task Groups" is the

"NOTS Advisory Board."* But while this was an organization in name only at this time, Thompson was studiously analyzing its possible role and potential.



Drs. C. C. Lauritsen and L. R. Hafstad, members of the first NOTS Advisory Board.

* Management by committee was apparently popular at NOTS in the postwar years. The list included the following: Research Board, Projects Assignments Committee, Section Committee, Projectile Committee, Air Launched Rocket Task Force, Committee on Rockets for Under-Water Use, Propellant Task Group, Blast Committee, Shaped Charge Committee, F7F GASR Committee, Foreign Rocket Task Group, Cafeteria Committee, Committee on Stockrooms, Warehouses, etc., Magazine Storage Committee, Committee on Procurement, Committee on Fuze Facilities at Morris Dam, NOTS Advisory Board, Committee on Range Meteorology, Military Requirements Committee, Ordnance Materials Inventory Committee, Committee on Classification of Documents and Drawings, Station Development Board, Committee for Laboratory Opening, General Tire and Rubber Company Contract Committee, and P.D.T&E Housing Committee. Strangely, two items seem to have been omitted: the NOTS Administrative Board and the Guided Missile Task Group.

Thompson saw the need for a group "who are experts in dealing with some phase of the work which is part of the primary work for this Station...expert in the field of physics or chemistry, or engineering work [with] broad foundations...or administrative experience in handling work of this sort...or have some combination of these qualities in operating industrial laboratories or other Government laboratories."³⁶

Most of the planning, organizing, and recruiting for the Advisory Board was done in 1947 and 1948 even though the first meeting did not occur until August 1949—a period beyond the scope of this volume. It is relevant to the present story, however, to note the efforts taken in the postwar period to keep NOTS in tune with the nationwide advances in technology.

LATENT IDENTITY CRISIS

No more Pasadena-related problems! A wishful thought that might have been held by many in the early spring of 1948. Yet, there was much evidence on the surface to support such an optimistic hypothesis.

Since head-on confrontation with the problems of OSRD-Navy transition in the turbulent early months of the postwar era, the combined efforts of the Bureau of Ordnance, CalTech, and those of the men of Inyokern and Pasadena had paid off: the earlier disarray of facilities, personnel, policies, and procedures had been pulled together into a cohesive administrative whole. Organizational channels were now clear; missions, tasks, assignments, responsibilities, and lines of authority clearly drawn. The Pasadena Annex was ostensibly an integrated and meaningful part of the Naval Ordnance Test Station.

There was further evidence, too, that all was going well in Pasadena. The Bureau was continuing to put a high priority on the torpedo development program, and accordingly was generous in the allocation of funding. The expensive variable-angle launcher facility at Morris Dam was progressing favorably—assured of its completion and planned formal dedication in early May 1948.

Moreover, in some ways the Annex was better off than its parent station. For example, the critical housing situation at Inyokern

had no counterpart in the huge metropolitan area of Los Angeles that adjoined Pasadena. Neither were the other morale-eroding inconveniences associated with the remote character of the upper Mojave Desert—cultural deprivation and extreme climate, to name only a couple.

On the surface, the Inyokern-Pasadena relationship seemed tranquil. However, in lower depths stirred the beginnings of a shifting current that presaged destructive waves unless a liberal application of soothing oil could be applied. But it was an elusive problem that was difficult to identify; which is not hard to understand as it concerned what people thought and felt, rather than what they did or said.

Importantly, although the personal relationship problem was barely discernible in the 1948 context, its root causes were already present and growing. What were these causes? Ironically, they stemmed from the identical source of strength and vigor that had carried the budding Annex through a difficult birth and enabled it to grow into a lusty, healthy youngster. Now, maturing fast, Pasadena was beginning to question the term “Annex”—which had for some the unfortunate connotation of “something tacked on”—and seek an identity all its own. Exactly what this identity should be was uncertain, but it could no longer be that of an alleged “stepchild of Inyokern.”³⁷

On the other side of the growing controversy, many at Inyokern felt that Pasadena was “getting too big for its breeches.”³⁸ While this assertion was probably valid, it still cast Inyokern in a familiar but unenviable role; namely, as the adoptive parent of an obstreperous offspring who was unusually talented and quite as mature as the parent.

STRIVING FOR AN INTEGRATED COMMUNITY

Thanks to the perspicacity of the NOTS planners (in Washington and on the local scene), most of the earlier problems associated with building a first class community integrated with the Station were well on their way to being solved by mid-1946. While budget difficulties and a severe housing shortage still persisted—giving rise, in turn, to some formidable administrative headaches—the Navy town of China

Lake was shaping up nicely after the first year of peacetime. But in the private sector "outside the gate," the community, especially the adjoining town of Ridgecrest, was encountering a situation of lesser stability. This principally stemmed from uncertainties regarding the future.

Basically, people who were not part of NOTS generally remained unimpressed by the Navy's repeated pronouncements that it was a permanent facility. This was evident in the sustained reluctance of the Federal Housing Administration to set up shop in the Indian Wells Valley, and the refusal of real estate brokers and investors to consider any large-scale development projects in the area. Consequently, in this period, most of the initiatives for community progress came from the Navy and were carried out at China Lake. There was relatively little private capital invested in Ridgecrest largely because of lack of confidence in the Navy's repeated statement that it was building a permanent station.

One of the few instances where private investment was not inhibited was seen in the establishment of a hospital in Ridgecrest (later the Ridgecrest Community Hospital). Dr. Thomas A. Drummond, a personable young surgeon, had operated an eight-bed hospital in the mining town of Red Mountain (some 25 miles from NOTS) until it burned down in 1944. Deciding to rebuild, he did so in Ridgecrest using his own funds. John Richmond later recalled the importance of Drummond's venture in terms of its relationship with the Navy's medical services:

When we first opened the [NOTS] Dispensary, it was open to both the military and civilian personnel. By regulation, we had to take care of the military personnel but [it] was quite a departure to send civilians over to a naval hospital and [it] caused some troubles, particularly after the war was over.³⁹

Richmond pointed out that the only other civilian hospitals were located at Mojave, Bakersfield, or Trona. He summarized Drummond's important role:

In the very early days when we didn't have the facilities, and the Navy was breathing down our necks about sending people to the Navy Dispensary . . . he really helped us out . . . when we needed help.⁴⁰

The fear of impermanency was not shared by the residents of China Lake. On the contrary, for most China Lakers the maturing process and a progressively uplifted morale had engendered an unusual optimism. After having seen the miraculous growth of Station and community—veritably, from the sagebrush and raw desert—how could it do anything but go forward?

At the top echelon of local management there was justification for optimism as the Bureau of Ordnance was constant in its assurance that NOTS was here to stay. It was more than just an implication, too. Not even the change of Bureau leadership in mid-1947 had made any difference. In fact, the new Chief had expressed his wishes for a "strong, important, and virile research program" at Inyokern and at White Oak.⁴¹

Although they were not privy to the Bureau of Ordnance's viewpoint, the rank and file shared an optimism that is just as easy to understand. After all, they had daily opportunity to contemplate the visible evidence for permanency: a multimillion-dollar laboratory building for which dedication plans were being made; the continuing work program to replace the temporary buildings with permanent ones; and the new construction programs for the test ranges, concomitant with a huge investment in sophisticated instrumentation facilities.

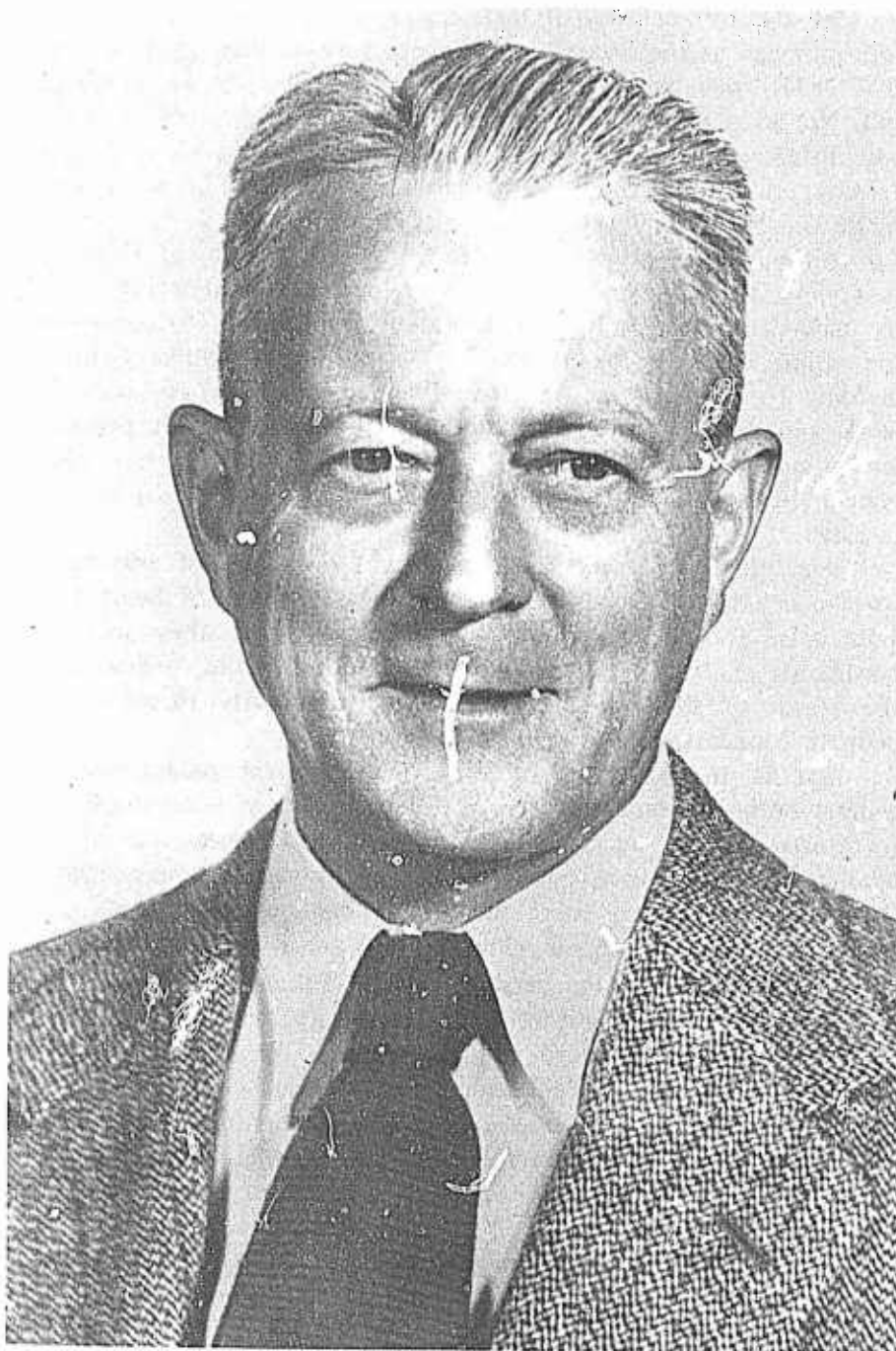
And there was still another *prima facie* item of evidence for permanency to NOTS residents. It surrounded them 24 hours a day. This was, of course, the community in which they lived: the hometown of 10,000 citizens designated "China Lake, California." In the minds of these citizens, the Navy community represented the bedrock foundation of a permanent station.

But in the judgment of the NOTS postwar management, the general optimism that pervaded at China Lake was not enough. They recognized that an operating community of good design and character would necessarily have to include the young, adjoining town of Ridgecrest; and indeed all of the civilian community elements in the Indian Wells Valley: schools, churches, and social organizations.

Accordingly, Station personnel—both military and civilian—were encouraged to participate fully in community activities "outside the fence," and they responded with enthusiasm. As a prime example, a president of the Indian Wells Valley's Parent-Teacher's Association was none other than the Station's dynamic Experimental Officer, "Chick" Hayward. Other naval officers served with equal distinction as Board Directors of the Concert Series and Orchestra—both combined community organizations.

Any success that might have resulted from the large-scale efforts to integrate the total community must be ascribed in great part to a man whom we have already met several times in this history: Commander John O. Richmond, the Station's first permanent Executive Officer.

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John O. Richmond, the Station's first Executive Officer and Community Manager.

When it was learned that Richmond's distinguished Navy career was to be closed out on June 30, 1946, upon his transfer back to the retired list,* it was quickly sensed that the loss would have a double impact upon NOTS. Richmond had skillfully managed to fulfill two functions simultaneously—that of expert Navy administrator as well as the principal architect and manager of a sizeable military-civilian community.

Thompson and Hayward could not countenance the loss and joined forces in doing something about it. They persuaded Captain Sykes (and the Bureau of Ordnance) that the special problems of a burgeoning community required the special talents of a community manager; an individual, as Richmond later recalled, who could be "the liaison between the military and civilian side of the family."⁴²

The timing of the recommendation couldn't have been better; it was the high season for "military-civilian relationship" issues at NOTS. The civilian post of Community Manager was promptly established, and "Mr." Richmond became its first incumbent.

Richmond's continued service at NOTS, although in a civilian capacity, had a profound and lasting effect on the Navy town of China Lake. During his tenure as Community Manager, school teachers and young scientists were encouraged to join the Officers' Club, and civilians were permitted to shop at a modified Navy commissary.

While many of these bonus privileges were retracted later, their granting in the first place was testimony to the efforts of men like Richmond to inculcate military-civilian harmony at the desert Station.

Richmond's goals for an integrated community reached far beyond the main gate at NOTS. In fact, the gate itself seemed to epitomize his drive: he recommended that it be removed to allow freer access for the Ridgecrest children attending the China Lake schools. But, as Richmond later recalled, "...Admiral Hussey wouldn't stand for it."⁴³

The NOTS Community Manager's relationship with local leaders and influential citizens became one of fast friendship. Nor was it confined to only the Indian Wells Valley, for Richmond's wide circle of friends included judges and lawmakers of Kern, Inyo, and San Bernardino counties. As a result, a lot of people got to know more about a relatively new desert Navy community called China Lake.

* It should be noted that this was Richmond's second retirement. His first retirement, due to ill health, ended twenty-three years of active service in 1926. In 1941 he was recalled to duty for the duration and assigned to Hawthorne because it had a dry climate that would not aggravate a chronic sinusitis condition.

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This invites speculation as to how outsiders might have regarded the NOTS community circa 1947-1948.

The question, What was China Lake *really* like in those days? can elicit an infinite number of responses when posed to "early timers" today. It would seem that a composite picture lies somewhere between "a desert paradise" (a phrase beloved of some NOTS recruiting brochures) and a "desolate hellhole." A balanced picture might be one contained in an article that appeared in the Station newspaper, the *Rocketeer*, on October 22, 1947, titled "Inside NOTS." Since it was written by a Station employee, A. E. Niederhoff, for an exclusive readership of other employees, we can assume that the article is reasonably close to the mark.

Niederhoff wrote enthusiastically about the community as being "stable, contented, and imbued with a [community] spirit that is reflected in the various social clubs, churches, lodges, and service organizations..." He was equally enthusiastic about the Station's two schools, Burroughs High School and the China Lake Elementary



First NOTS Chapel, formerly "the old movie hut," October 1947.

School, which now had a total enrollment of 1,100 pupils. Shops, stores, and recreational facilities (such as the theater, bowling alleys, and swimming pools) also received feature billing in the article.⁴⁴

But in his word picture of the NOTS community, one pauses to wonder whether there was just a tinge of rose color in the writer's glasses. Although many salutary attempts had been made by the residents to realize "beautiful, grassy spaces surrounding the homes... vines, hedges, flowers, and young trees... walled patios," the community was by no means picturesque. In fact, the casual visitor might have been somewhat less than impressed by the amorphous array of austere buildings that dotted the raw desert landscape; all the same color—an uninspiring gray, intermixed with structures of raw cement.

But, like Niederhoff, the majority of China Lakers inherently possessed the vision to perceive the community's potential; looking forward to a time in the future when the trees would grow tall and the essential rawness of the new buildings would mellow.

In time, too, the citizens of the outside communities would come to regard the Naval Ordnance Test Station as a permanent entity. With this acceptance would come a more pronounced confidence in the future and a willingness to ally the destiny of their respective communities with that of the desert Station.

A TRADITION CONTINUES

One of the strongest believers in the permanency of NOTS was its first Commanding Officer, Captain S. E. Burroughs. A measure of his belief is seen in the early establishment of a tradition whereby the Station's history is commemorated in the names of its streets and avenues; Burroughs' philosophy was that eventually the total history of NOTS should be represented by street names that call to mind the significant people, places, and ships that have helped to shape or even lightly touch the destiny of the Station. Long after Burroughs' departure the tradition was perpetuated.

Among the first names chosen were those of famous Fleet Admirals: Nimitz, King, and Halsey. These were followed by Chiefs and Deputies of the Bureau of Ordnance: Hussey, Blandy, and

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Parsons and other prominent Bureau names such as Byrnes, Kitts, Tyler, and Entwistle.*

Civilians who played a prominent part in the NOTS story are remembered: Knox Road and Forrestal Street for two Secretaries of the Navy and Bard Street for Ralph Bard, Undersecretary of the Navy, and Thompson Street for the first Technical Director. The memories of CalTech men who helped plan and build the Station are also preserved: Fowler, Ellis, Bowen, Sage, and, of course, Lauritsen.

In the distinguished chronology of names, each Commanding Officer is honored. However, in 1948, only one name had been used: Burroughs High School. Eventually Sykes Circle and Switzer Circle would emerge from the period of history covered by this particular volume. The first Experimental Officer, Chick Hayward, and the first permanent Executive Officer, John Richmond, would similarly have streets named after them (Richmond would also give his name to an elementary school).

Not only are the men honored, but also their famous ships—*Hornet*, *Wasp*, *Franklin*, *Intrepid*, *Saratoga*, *Kearsarge*, *Lexington*, *Essex*—and Jimmy Sykes' own *Bennington* and *Card*. There is Navy tradition reflected, too, in the streets named after the famous combat arenas in which these ships did battle: Midway, Leyte, and Coral Sea.

Thus, a tour around the Naval Weapons Center today is a veritable guidebook through its history, with each signpost providing a fleeting nudge of memory to recall its prominent historical principals.

One name, in particular, is most significant—the name given to the brand-new research laboratory. While it was an eminently distinguished name in the annals of science and naval ordnance, the individual so honored had no association whatever with NOTS Inyokern.

The name was Michelson.

* An amusing story, although beyond the period of this volume (circa 1950), finds Bureau Admirals Snackenber and Schoeffel good-humoredly discussing the fact that their names had been overlooked at China Lake. They sent a mock formal message to the (then) Commander, Captain Vieweg, pointing out that a short alley on the Station was still without a name. The admirals suggested that it be called "Snackenber-and-Schoeffel Street" with the idea that the name would appear longer than the street.

Vieweg went one better. He named the Station's large, new athletic area "Schoeffel Field"; a humorous irony that recalled to the many Navy and Bureau of Ordnance comrades of Admiral Schoeffel that of all his Academy class he had been the least known for his athletic prowess!

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NA National Archives, Washington, D.C.
LTET Papers of L. T. E. Thompson, Scarsdale, New York

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Landfall: Michelson Laboratory

May 8, 1948, was a significant day for NOTS. For one thing, it marked the third anniversary of Germany's defeat in World War II; in another three months, the Station would be embarking on its third year of peacetime operation.

It had been four and a half years since NOTS was established in crisis, to be embroiled immediately in the war and its mounting demands for new rocket weapons. Victory had not realized an abatement of turbulent times; indeed, conflict had continued to characterize the desert Station's entire existence throughout the first uneasy years of peace. At stake was the survival of NOTS as envisioned in the original concept for an integrated naval ordnance research and development center.

But now, in the spring of 1948, there was strong evidence that the concept had been preserved. The epitome of such evidence was figuratively—and literally—concrete: the NOTS research laboratory.

DEDICATION

Beautiful days are characteristic of the Mojave Desert in late spring; some NOTS early-timers of good memory recall that Saturday, May 8, 1948, was just such a day. The occasion was one of the major milestones of the total NOTS story. It was the day that the Michelson Laboratory was formally dedicated.

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The 3,800 civilians and 1,000 military personnel of NOTS at this time also recognized the importance and significance of the dedication ceremony. A memorial coin had been designed and struck, accomplished entirely at the Station, duplicating methods used by the U.S. Mint for the manufacture of coins. A quiet, tasteful commemorative booklet published on the anniversary of the dedication a year later described the new facility:

Michelson Laboratory is regarded as one of the most complete research facilities of its kind in the world. Built at a cost of \$7,000,000, it contains more than 9 1/2 acres of floor space. The structure is made up of 16 monolithic concrete units, joined in such a way as to prevent possible earthquake damage. Its long horizontal lines parallel the planes of the desert. Concrete louvers, projecting from the outside walls, diffuse the intense sunlight, and the laboratory is air-conditioned throughout. Designed to accommodate a staff of about 600, it is equipped for basic and applied research in physics, chemistry, aerophysics, metallurgy and ballistics, and for development work on propulsion, fire-control, and guidance systems for rockets and other missiles. Among its service facilities are a technical library, a large and versatile machine shop, a foundry, and standards of measurement, materials testing, heat-treating, and electroplating shops. Testing rooms in which it will be possible to simulate any kind of weather, from the blistering heat of the tropics to the deadening cold of the poles, are being completed.¹

The NOTS leadership and distinguished guests who were to participate in the ceremony were also keenly aware of the achievement represented by the impressive new research and development laboratory. These included Rear Admiral W. G. Switzer, NOTS Commander; Dr. L. T. E. Thompson, Technical Director; Rear Admiral A. G. Noble, Chief of the Bureau of Ordnance; the Honorable John Nicholas Brown, Assistant Secretary of the Navy for Air; and Dr. C. C. Lauritsen of CalTech.

The dedication ceremony also served to honor the man for whom the laboratory was named: Albert Abraham Michelson, distinguished naval officer and physicist, and the first American recipient of the Nobel Prize in science. Present at the dedication were three daughters of Professor Michelson: Mrs. Festus Foster, Waterford, Virginia; Mrs. William D. Stevens, New York City; and Mrs. Nevile Gardiner, Washington, D.C. Nobel Prize winner Dr. Robert A. Millikan, Professor of Physics Emeritus and chairman of the Executive Council at the California Institute of Technology and for twenty-five years an intimate associate of Professor Michelson, was to deliver a memorial address.

At the opening of the ceremony, the U.S. Marine Corps Band from San Diego played with spirit, their instruments catching and reflecting the bright desert sunlight. It was a joyous occasion calling for the presence of everyone who had dreamed of a permanent Navy

ordnance research and development center and who deserved credit for his part in fulfilling this dream. Unfortunately, this was not the case. Old photographs reveal that the specially constructed bleachers in front of the new laboratory were not filled. Arrangements with the Southern Pacific Railroad for special Pullman service from Los Angeles to NOTS never materialized because of failure to meet a minimum guarantee as to the passenger volume.²

The proposed invitation list (nearly 1,000) comprised some 15 categories of visitors headed by "President of the United States and Cabinet Members." Others included senators, governors, university presidents, deans of science schools, and industrial contractors.³

Perhaps the Station organizers of the dedication ceremony were secretly relieved that there was no great influx of visitors. There were as yet virtually no hotel accommodations in the surrounding community, and the housing shortage on the Station was still critical. As one old-timer recalled, "If everyone who was invited had shown up, we wouldn't have known where to put them."

Among the Bureau of Ordnance notables who were not present were two remarkable naval officers who had been largely instrumental in bringing NOTS, as well as the Michelson Laboratory, into being.

The first of these was Admiral W. H. P. Blandy, who, as a former Chief of the Bureau of Ordnance, had been the most visionary prophet of a permanent, postwar Navy ordnance research center. "Spike" Blandy was now Commander in Chief, Atlantic Fleet.

The other was Captain James C. Byrnes, Jr., the former watchdog of the Bureau of Ordnance's shore establishment. This extraordinary officer had been more than a visionary; he was a man of action. As the recognized spokesman for the Bureau Chief in the first months of the Station's history, Byrnes' voice had loudly and clearly been heard in congressional appropriations offices, Bureau of Yards and Docks design and drafting rooms, and over the busy telephone lines linking Washington and Inyokern. His administrative wisdom had done much to make Michelson Laboratory a reality. "Doc" Byrnes would be remembered *in absentia* on this bright day in May 1948.*

* The fact that Byrnes did not receive an invitation was a matter of regret for Richmond, and perhaps others, for years to come. It appears that the invitation was mistakenly sent to a Captain J. F. Byrne who, by a strange quirk of irony, was on duty at the Bureau of Ordnance. Hence this officer probably received the invitation and declined to come. At this time (1948) James C. Byrnes, Jr., had been on the retired list for three years. While it is satisfying to set the historical record straight, it is particularly poignant that the reason for the "missing invitation" was not learned by "Doc" Byrnes before his death in 1967.

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But most of the principals in planning and making the laboratory a reality were present. Vice Admiral George F. Hussey (Ret.), Blandy's successor as Chief of the Bureau of Ordnance and another principal architect of the NOTS dream, arrived by air on the same airplane as Assistant Secretary of the Navy for Air J. N. Brown, Rear Admirals A. G. Noble, F. E. Beatty, and Turner Joy, and Captain S. E. Burroughs, first Commanding Officer of NOTS.

For some of the participants, notably Admiral Switzer, Dr. Thompson, and some senior staff members, this was a second day of continuing celebration for NOTS: Friday, May 7, had been the occasion of formally dedicating the variable-angle launcher (VAL) at Pasadena's Morris Dam facility.

By comparison, the scope of the previous day's activity was modest with a tone set by the keynote speaker, Dr. W. V. Houston, distinguished president of Rice Institute, Texas, and CalTech alumnus. He spoke at length about the role of research and the application of science to the national defense, saying, "In a race the prize goes to him who runs the fastest." The military defense of the United States, he declared, "requires that the state of science and technology throughout the whole country be pushed forward." He concluded, "And to this end, I am sure that this new Morris Dam installation will make a magnificent contribution."⁴

Then it was time to demonstrate the VAL. To the great relief of those who had witnessed a startling premature launching on the previous day's rehearsal, the demonstration torpedo launched perfectly. The NOTS dedication ceremonies were off to a fine start!

On May 8, 1948, NOTS Inyokern had been in existence for exactly 1,642 days. But of all those days, this one was exceptional—a day to remember for those of NOTS who attended the ceremony. Some of these men and women had been a part of the Station almost since its inception four and a half years earlier. Perhaps their thoughts touched on less happy days, in wartime and the equally difficult time of peace that followed hard upon it, when the struggle to keep the NOTS concept alive had been particularly intense.

But any such serious retrospection would have been fleeting on this sunny Saturday afternoon. Rather, this was a time to consider achievement and the future significance of the new laboratory to the continuing needs of national defense in a technologically complex world.

LANDFALL: MICHELSON LABORATORY



Michelson Laboratory at the time of its dedication, May 1948.

The color guard completed their opening ceremonies and Rear Admiral W. G. Switzer, NOTS Commander, gave this address of welcome:

The Laboratory itself is a symbol of permanence and security; permanence of homes and employment, and the security which it insures. It is evidence of the faith of the Navy and the nation in the ability of the individuals who will work here to meet their responsibilities toward the Navy's efforts to provide security for the nation and thereby promote a lasting peace.⁵

NOTS was the Bureau of Ordnance's baby. It was appropriate therefore that the Chief of the Bureau of Ordnance be a principal speaker. Rear Admiral Albert G. Noble was the third Bureau Chief who had nurtured and protected the infant and ensured that it would, in Fred Hovde's words, "withstand the rigors of peacetime malnutrition." He spoke for Bandy and Hussey, and also for the dedicated men and women in the Bureau who would always be aware that a significant part of their lives was irrevocably linked with this corner of California's Mojave Desert.

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Noble reminded his audience that in the absence of potential enemy surface forces, the Bureau was concentrating its efforts in three major fields of ordnance development—the aircraft program, the anti-aircraft program, and the antisubmarine program. He concluded:

It is significant that today we are present to dedicate this laboratory at an ordnance station in which important portions of all three of the research programs are being effectively undertaken. The adequacy of the facilities and the technical competence of the staff give cause for full assurance of the satisfactory solution of the problems assigned here.⁶

Mrs. Nevile Gardiner, Michelson's daughter, then addressed the assembly. She spoke briefly in acknowledgment of the honor paid her father's memory, expressing on behalf of her sisters and herself a gratitude at being able to share in the dedication of the laboratory. She said her father would indeed have felt proud could he have been present, and concluded by stating, "I know that this new research laboratory has my father's blessing. It has our most confident and heartfelt wishes for success."⁷

The wonder of NOTS, both in its evolution and its concept for future operations, could be seen in the smooth intermixing of speakers with gold braid and multicolored military ribbons and those in business suits and fine dresses. Leading the list of distinguished speakers in civilian attire was the Honorable John Nicholas Brown, Assistant Secretary of the Navy for Air. The Secretary addressed his remarks largely to the NOTS scientists, using as his theme, "Integration of Scientific and Military Effort in Weapons Research."

The Secretary deplored the idea that war was inevitable, but called attention to existing circumstances resembling those that led to past wars. He therefore felt it would be "rash and foolhardy" not to prepare actively for the nation's defense. In this context, he said:

If there is to be another war, the shape of it first will be visualized here at China Lake. Each time I come here I have an impression that I am being given a look into the future. Here many of the weapons of the next war will have taken shape first in the minds of some of you now present. Here men in pursuit of elusive truths will find themselves diverted by their own discoveries down new and unsuspected paths to fresh fields hitherto unknown. Having evolved in men's minds, new weapons will be devised in the magnificent laboratory we are dedicating today. They will essay their first flights in the reaches of the desert which surrounds us. Here they will be tested, studied, altered and perfected before other people in other places take up their manufacture and send them on to the armed services for use. . . .⁸

If today was a proud day for NOTS, it was equally so for the unassuming man in a blue serge suit who now took his place by the side of the Assistant Secretary on the speaker's rostrum—Dr. Charles C. Lauritsen of CalTech. To John Nicholas Brown fell the honor of

presenting Lauritsen with the Medal for Merit. The citation, signed by President Truman, read in part, "for exceptionally meritorious conduct in the performance of outstanding services to the United States from July 1940, to June 1946"; it went on to catalog a list of accomplishments, which, according to the citation, "did much to shorten the war and saved the lives of many of our fighting men." Both the nation and the Navy were grateful to the desk-pounding scientist who led the way in making rockets a vital weapon for the armed forces of the United States.

Then it was time to honor the man for whom the new laboratory had been named: Dr. Albert Abraham Michelson (1852-1931).

There was never any question as to the appropriateness of the name—ever since it had first been suggested for the new NOTS laboratory. James Duncan, who had been a student of physics under Professor Michelson at the University of Chicago in 1919, is credited by Thompson for suggesting the name. In a later interview, Duncan said, "When I went to the Naval Academy . . . I began to think it was a shame that the Navy didn't have any laboratory or building named for Michelson. . . . I even suggested it there, but they weren't in a position to do anything about it at that time. . . . So when I became associated with the plans for the laboratory at NOTS, of course, this was the first thing I thought of . . . here's a chance to get it named for Michelson."⁹ It was a good choice, for not only had Michelson been a naval officer, but he was also one of the nation's most distinguished scientists.

After graduation from the United States Naval Academy in 1873, and an ensuing tour of two years at sea, Ensign Albert Michelson was ordered back to Annapolis as an instructor in physics and chemistry.

After twelve years in the Navy, Michelson became, as he described himself to the press many years later, "a sailor who degenerated into a college professor because it thrilled him to match wits with inanimate objects."¹⁰

In 1907 he became the first American scientist to be awarded the Nobel Prize in Physics. This was "for his precision optical instruments and the spectroscopic and metrological investigations conducted therewith."¹¹ He became known as "the man who taught a world to measure"; his experimental values for the velocity of light were accepted as the most accurate for nearly two generations; and he was the first to measure the diameter of a star, as well as to determine the length of the standard meter in wavelengths of light—a natural and reproducible phenomenon.

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In his rise to world eminence as a scientist, Michelson's loyalty to the Navy did not diminish; nor did his interest in the application of science to the defense of the nation. Five of his patents are for optical range finders (designed for the Bureau of Ordnance between 1891 and 1919) and a sixth (with John Gordon Wilson) is for a device to protect the ear diaphragm from the noise of gunfire.

During World War I, he again donned a Navy uniform to serve on active duty as scientific consultant to the Bureau of Ordnance. In this capacity he continued his work on range finders, represented the Bureau in technical commissions, performed development work on such diverse items as binoculars for night observation and instruments for plotting aircraft courses, and provided scientific leadership in solving critical problems in the development of a domestic source for optical glass in the United States.¹²

And so, the name chosen for the new laboratory at NOTS was a fitting symbol of the close cooperation between naval personnel and civilian scientists, so vital to the success of the young desert Station. And this spirit was much in evidence on the bright Saturday in May 1948 when Dr. Millikan rose to make the keynote address of the dedication ceremony.

Millikan bore his 80 years with dignity and evident pride. It was pride deserved. He was one of the first scientists to answer his country's call in both World Wars I and II. And in the years between, when few of his colleagues felt an obligation or the need to aid in the nation's defense, he worked to develop couplings between the scientific and military communities. So on this spring day on the desert he could be especially proud of his close scientific association and long personal friendship with Michelson that went back to the 1890s when he undertook an assistantship under Michelson at the University of Chicago.

Millikan's testimony to his old teacher, associate, and personal friend was spoken from the heart.

I am quite certain that the last thing Professor Michelson would have desired would be to have this memoir made merely a eulogy. I am therefore endeavoring to give . . . as correct a picture as I can of the man as I knew him through more than twenty-five years of intimate association.

Millikan then spoke of a man whose outstanding characteristic was honesty; also, of one whose other notable characteristics were "singleness, simplicity, and clarity of his objective—an objective from which he let nothing divert him, however great the pressure." Michelson the scientist was described by Millikan as a pure experimentalist, designer of instruments, and a refiner of techniques.

He lives, Millikan declared, "because in the field of optics he drove the refinement of measurement to its limits and by so doing showed a skeptical world what far-reaching consequences can follow... and what new vistas of knowledge can be opened up by it. It was a lesson the world had to learn."¹³

At the close of his address, Millikan unveiled a handsome oil portrait of Michelson that was earmarked for permanent display in the lobby of the new laboratory.

While this was the time to be proud, to reflect, and to pay tribute, it was also a time to try to grasp the meaning of NOTS within the broad perspective of national defense. What was the significance in all of this—the new laboratory; a flourishing research, development, and test program; a community thriving in the desert; and the unique but tangible bond between the military and civilians who sat there side by side?

Nobody present at the dedication ceremony, or in the entire field of naval ordnance for that matter, was more qualified to give voice to this meaning than the Technical Director of NOTS, Dr. L. T. E. Thompson. To him the new Michelson Laboratory in the backdrop of the speaker's platform was the culmination of a dream come true.

It had been twenty-five years since he had become the first Chief Scientist at the Naval Proving Ground, Dahlgren, Virginia, and during the quarter century no other scientist had striven harder to improve the means by which the Navy could develop advanced weapon systems. Thompson had been among the first in the post-World War I period to recognize the need for an ordnance laboratory within the Navy. He knew also the vital importance of civilian scientists working directly with the military to produce weaponry.

Now, as Technical Director, he was the scientific leader of an integrated organization where the whole process of weapon development could be accomplished—from initial idea through all the steps to Fleet introduction. Through his own foresight and untiring efforts he had led in the shaping of this organizational concept and in getting it accepted and implemented.

Thompson spoke first of the requisites for effective national preparedness and posed the questions: "What constitutes adequate strength, and by what allocations of our national effort and of our available facilities for cultivating preparedness will best results be had?" Inyokern, he said, was one link in the national facilities for dealing with the complex problem of combat analysis.

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Thompson then delivered what he termed "a sort of report on the state of the Station in respect to those questions which have seemed for three years [to be] of greatest importance to successful operation." He pointed out the principal differences that set NOTS apart from other centers: namely, the provision in one location of research laboratories, shops, pilot plants, ranges, and a self-contained community comprising homes, stores, hospital, and recreational facilities. All the advantages of such an integration, he concluded, "justified the decision to build one technical center and town out here in the Mojave Desert."

The Principles of Operation and their significance to the grand experiment at Inyokern were particularly stressed by Thompson, who said:

Possibly the most significant experiment so far conducted at this Station is the one to establish a new type of organization and operation for a research center staffed by a mixed group of civilian scientists, engineers, and naval personnel, operated within the framework of Navy administration. . . . In it there is clear acceptance of the principle that directional control of a development program is a job for civilian technical personnel. The Navy has recognized that there must be maintained in this center an environment for work and for community life more like that of an industrial or university laboratory than of a military regime. It has fully recognized that the chance for operation on a level comparable with the levels attained by the highly successful OSRD groups during the war rests entirely on our ability to attract and hold a technical staff of high qualifications. At the same time, we believe that close collaboration by the operations experts of the armed services and the development staff at China Lake is essential in providing the guide lines for a successful weapons development program. . . .¹⁴

Thompson did not skirt operational problems still facing NOTS; for example, "difficulties in adapting civil service employment precedents and government procurement procedures to the needs of a research and development center, and inadequate appropriations for travel and telephone communications." But while he gave visibility to the problems, Thompson was quick to stress that "progress is being made toward [their] solution."

As he articulated his thoughts on the future role of the Station, it was perceived by all that the original vision of a weapons development center still burned brightly for the NOTS Technical Director. "The Navy," he said, "recognizes that fundamental science must furnish the stimulation and the foundation for development work." He added, "... it has established at this Michelson Laboratory an already strong department for basic and applied research."

Thompson affirmed his belief that a weapon development center's job stretched beyond producing components for weapons to

sharing a responsibility for training young people in the various technical fields, and further "...to collaborate in the conduct of basic research on which technical progress and much of our economic progress must eventually depend." In this regard, he pointed out that a contribution to the scientific foundation for a weapons program would likely be a contribution to the scientific foundation for a whole zone of industrial development.

In conclusion, Thompson summarized his credo as follows:

We believe such a station has a degree of responsibility in helping with the program to build, in proper balance, all components of national strength...adequate progress toward the prevention of war through properly balanced strengths will be found also to have produced that kind of national strength necessary for highest levels of peaceful living.¹⁵

SOME MONDAY MORNING THOUGHTS

The ceremony was over; the new laboratory at NOTS was truly dedicated. Transportation by road and air was replayed, this time bearing the distinguished visitors back from whence they had come to take part in the May 8, 1948, proceedings. The bleachers were taken down, and for the employees it was a relatively normal Monday morning that they faced.

But for the majority of these uniformed and civilian workers, there was now a subtle change in their regard for the Station. A new, provocative flavor had been infused into the NOTS brew, which was now already on its way to acquiring a vintage character. The many tributes and good words that had been voiced from the speaker's rostrum two days earlier embraced a quality that went far beyond the nature of an inspirational pep talk; there was fact, logic, reason, and hope in the various addresses by the nation's representative military and scientific leaders. In sum, these leaders were reaffirming that the original concept had not been lost—that NOTS would fulfill its destiny as a center for the "research, development, and testing of weapons" described in the original founding order written exactly four and a half years earlier.

There was now a difference. The concept had survived the transition from idea to reality; from war to peace; from a barren desert site to large complexes of technical facilities near the Navy-built community of China Lake and near Pasadena; from a center for rocketry to one for a broad spectrum of weaponry; from a military organization to a unique military-civilian team; and from a

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test station and experimental production facility to a research, development, and test center. The grand experiment at Inyokern had been judged successful.

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14. *Ibid.*, p. 11.
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NOTS Chronology

June 1943 to June 1948

Selected events are listed that led directly to the establishment of the Naval Ordnance Test Station and continued to represent significant milestones during World War II and the critical postwar period that followed.

1943

- June 7 Directive from the Commander in Chief to the U.S. Fleet calls for large aircraft rocket program at CalTech that was to provide basis for expansion of West Coast rocket facilities, including test ranges.
- July 14 First air launch of a forward-firing rocket, using British rounds, as part of the CalTech rocket program.
- Aug. Dr. Charles C. Lauritsen and Commander Jack C. Renard, during flight over Mojave Desert, are impressed with Inyokern area and dry China Lake as site for proving ground.
- Aug. 20 First air launch of CalTech-developed forward-firing rockets, the "CIT Type High velocity 3A12."
- Oct. 19 Vice Chief of Naval Operations orders 6,000 airplanes to be equipped with the new forward-firing rockets and launchers by June 1, 1944, with 4,500 earmarked for the Pacific Fleet.
- Oct. 28 Vice Chief of Naval Operations gives verbal approval to start construction of temporary facilities at Inyokern.
- Oct. 28 First funds for temporary facilities made available for NOTS—\$160,000 for "expedition of the rocket program."
- Oct. 29 Agreement reached among government agencies whereby Navy obtains use of Inyokern airfield.

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- Nov. Captain A. K. Fogg, first Officer in Charge of Construction (Acting) for NOTS, expedites temporary building program and paves the way for planning and constructing permanent facilities. Quonset huts arrive by rail at Inyokern.
- Contract let to Macco Construction Co. for work on temporary facilities at NOTS.
- Construction started on first NOTS aircraft and ground ranges: C-1, G-1, and G-2.
- Nov. 8 NOTS officially established by the Secretary of the Navy.
- Nov. 9-16 Facilities plan for NOTS prepared by naval officers and CalTech scientists under the leadership of Commander K. M. McLaren.
- Dec. 3 First test on NOTS ranges, air launching of 3.5-inch rockets against ground targets (to study fuze functioning), marks "the beginning of operations at NOTS."
- Dec. 7 U.S. spinner rockets test-fired at Goldstone Lake.
- Dec. 10 Rear Admiral George F. Hussey relieves Rear Admiral W. H. P. Blandy as Chief of the Bureau of Ordnance.
- Mid Dec. First ground firings of "Holy Moses," 5-inch high velocity aircraft rocket (HVAR), at Goldstone Range.
- Dec. 21 Captain Sherman E. Burroughs, Jr., arrives at Inyokern and assumes command of NOTS.
- Aviation Ordnance Development Unit No. 1 (AODU-1) commissioned at the Naval Air Station, San Diego.
- Dec. 31 Secretary of the Navy James V. Forrestal requests Department of Interior to acquire desert land for exclusive Navy use.
- 1944
- Early Jan. Fleet pilot training program in use of rockets begins at NOTS.
- Jan. 2 First contingent of AODU-1 arrives at Inyokern.
- Jan. 11 First confirmed "kill" of enemy submarine made with the "CIT Type High Velocity 3A12" rocket.
- Jan. 12 Site plans and schematic drawings of NOTS facilities completed.
- Jan. 15 Captain Oscar A. Sandquist, Officer in Charge of Construction, takes charge of NOTS building program for its year of greatest expansion.
- Jan. 17 Bureau of Ordnance approval for 20 Quonset huts and two Stran Steel buildings to be constructed at China Lake rather than Inyokern confirms new location for NOTS headquarters.
- Jan. 22 Plans developed to locate a new pilot plant for the production of rocket propellants at NOTS and to name it the China Lake Pilot Plant.

NOTS CHRONOLOGY

Feb.	Ground firings of rockets begin on NOTS ranges.
Feb. 1	Secretary of the Navy releases the \$9,500,000 approved by Congress for the construction of NOTS.
Feb. 15	The Bureau of Ordnance releases \$1,500,000 for construction of the China Lake Pilot Plant; additional funds for equipment.
	First U.S. aircraft rockets used in combat in the Pacific Theater.
	Carrier Aircraft Service Unit No. 53 (CASU-53) commissioned at NOTS by the Chief of Naval Operations to service and maintain aircraft of training squadrons at Inyokern.
Feb. 24	A letter of intent issued for the main construction contract for NOTS.
Mar. 16	Permission obtained for NOTS to use Haiwee Reservoir as a range to study underwater trajectories of rockets.
Mar. 30	First rockets fired from G-2 ground range.
	First air firing of Holy Moses successfully conducted at NOTS.
Apr.	NOTS command moves to China Lake from the Inyokern airfield.
	Commander John O. Richmond reports for duty as Executive Officer at NOTS, replacing Lieutenant Commander J. T. Acree.
	"Tiny Tim" (11.75-inch aircraft rocket) successfully launched from NOTS ground ranges.
May	Construction of China Lake Pilot Plant begins.
	Air facility at Harvey Field, Inyokern, designated U.S. Navy Air Facility, Inyokern, placed under NOTS Commanding Officer.
June	Decision is made to build large new air facility (subsequently named Armitage Field) on the Station proper for the testing of experimental weapons.
June 5	AODU-1 officially transfers to NOTS Inyokern.
June 22	First air firing of Tiny Tim at NOTS.
June 28	The Inyokern airfield is officially dedicated as Harvey Field in honor of Lieutenant Commander Warren W. Harvey.
July	Holy Moses is ready for combat use; establishes new leadership for the United States in aviation ordnance.
July 15	Holy Moses first used in battle (against targets in the Saint-Lô area).
Aug. 4	Commander John T. Hayward becomes first Experimental Officer at NOTS.
Aug 21	Lieutenant John M. Armitage killed while test firing a Tiny Tim at NOTS.

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Aug. 23	Seagoing tests of the 5-inch high velocity spinner rocket (HVSR) are successful.
Oct.	Twelve-inch propellant press line completed at China Lake Pilot Plant.
Fall	Foundations poured for NOTS research laboratory.
Oct. 7	First forward-firing aircraft spinner rockets ground-tested at Inyokern.
Nov.	Lieutenant Commander Curtis F. Vossler relieves Lieutenant Commander Thomas F. Pollock as Officer in Charge of Harvey Field and AODU-1.
Nov. 16	First grain of ballistite propellant extruded from 12-inch press at China Lake Pilot Plant.
Dec.	Holy Moses introduced to the Fleet.
1945	
Jan. 1	Initial planning meeting (Major General Leslie R. Groves of Los Alamos, Captain W. S. Parsons, Dr. Charles Lauritsen, and Dr. Bruce Sage) for the building of a pilot plant (later named Salt Wells Pilot Plant) for "nonnuclear explosive components of atom bombs."
Jan. 22	Contract arrangements made for services of Dr. L. T. E. Thompson in planning for the peacetime research and development organization of NOTS.
Mar. 7	Secretary of Navy approves NOTS acquisition of 241,000 acres as an extension of its northern boundaries.
Mar. 24	Dr. L. T. E. Thompson proposals for the new research and development organization at NOTS are completed. He assumes post of Acting Director of Research.
Spring	Technical work by CalTech for the Manhattan Project begins; known as Project CAMEL (nonnuclear explosive components of atom bombs and including air drops of bomb shapes).
May 8	<i>World War II ends in Europe; V-E Day.</i>
Late May	NOTS Naval Air Facility transfers its pilots, planes, and equipment from Harvey Field to Armitage Field.
May 29	CalTech Type 2 rocket sights go into combat on aircraft aboard the carrier U.S.S. <i>Gilbert Islands</i> .
May 31	Work halted on all construction at NOTS.
June 5	Meeting at CalTech on transfer of rocket program to Navy control and termination of OSRD Contract OEMsr-418.
July	Transfer of rocket production activities from CalTech to General Tire and Rubber Company.

NOTS CHRONOLOGY

July 25	First high explosives for use in atomic bombs are cast at Salt Wells Pilot Plant.
Aug.	Test program for Bumblebee guided missile transferred to NOTS. Guided missile testing begins at NOTS on G-Ranges.
Aug. 4	Research Board established at NOTS.
Aug. 6	<i>Atom bomb dropped on Hiroshima.</i>
Aug. 9	<i>Atom bomb dropped on Nagasaki.</i>
Aug. 14	<i>World War II ends; V-J Day</i>
Aug. 15	The transition of NOTS from wartime to peacetime operation begins.
Aug. 18	Captain Burroughs leaves NOTS; Captain James B. Sykes assumes command.
Sept. 1	Transfer to NOTS of underwater ordnance test facilities at Morris Dam.
Oct. 20	Guided Missile Task Group organized at NOTS by Dr. Thompson.
Dec.	Reorganization of NOTS is first to reflect NOTS peacetime mission of research, development, and testing of weapons. Dr. L. T. E. Thompson becomes permanent Director of Research.
Dec. 1	Target date for transfer to NOTS of the China Lake Pilot Plant and associated activities.
Dec. 31	Target date for termination of all Office of Scientific Research and Development experimental activities related to NOTS. Target date for termination of CalTech's experimental work on propellants and interior ballistics.
1946	
Jan.	\$5,000,000 contract awarded for completion of the research laboratory at NOTS (later named Michelson Laboratory). Construction of Salt Wells Pilot Plant completed.
Mar. 5	NOTS Administrative Board established.
Apr.	Harvey Field closes.
June 30	Commander John O. Richmond retires from the Navy and becomes the first Community Manager at NOTS. Commander Alcorn G. Beckmann replaces him as Executive Officer.
July	Bureau of Ordnance requests NOTS to develop a 1,000-pound high-speed, straight-running torpedo.
Oct. 21	Principles of Operation for NOTS approved by Vice Admiral G. F. Hussey, Chief of the Bureau of Ordnance.

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1947

- Mar. Bureau of Ordnance requests development of a folding-fin version of the 3.25-inch fin-stabilized aircraft rocket (FSAR); this led to development of the 2.75-inch FFAR, the Mighty Mouse.
- Mar. 28 Bureau of Ordnance approves first missile development program for NOTS.
- Apr. 28 Secretary of the Navy directive places the Naval Air Facility under the military command and coordination control of the NOTS Commanding Officer.
- Nov. 5 Rear Admiral Wendell G. Switzer assumes command of NOTS.
- Dec. NOTS reorganization for peacetime mission of research, development, and testing of weapons is accomplished.
- Dec. 19 Public Land Order 431 grants the Navy clear title to Station lands formerly under public domain.

1948 (to June)

- Jan. 26 China Lake post office established.
- Mar. Two successful supersonic beam-riding flights conducted at NOTS establish historic milestone in guided missile development.
- Spring Active development of Mighty Mouse 2.75-inch aircraft rocket begins.
- May 7 Variable-angle launcher (VAL) at Morris Dam formally dedicated.
- May 8 Michelson Laboratory formally dedicated.

Appendix A

List of Planned Facilities and Construction for NOTS (January 1944)

APPENDIX A

AREA "A", TRAINING AIR CENTER

	Estimated Project Cost
A- 1 Administration Building	\$ 65,000
A- 2 School	54,500
A- 3 Dispensary	61,000
A- 4 BOQ (200) Officers (5)	193,500
A- 5 Officers Mess and Rec.	63,500
A- 6 B-1-B Barracks (1000) (4)	240,000
A- 7 Men's Mess hall and galley	114,000
A- 8 Men's Recreation and Ship Service	78,000
A- 9 Wave Officers Dormitory (20)	25,000
A-10 Wave Barracks (200)	85,000
A-11 Wave Recreation and Ship Stores	26,500
A-12 Wave Mess hall and galley	32,000
A-13 Fire House	7,500
A-14 Brig	25,000
A-15 Gymnasium	35,000
A-16 Public Works Shops	26,500
A-17 Transmitter Building	5,000
A-18 Storehouse (with platform) (4)	120,000
A-19 Storehouse (no platform) (4)	62,000
A-20 Paint and Oil Storage	2,000
A-21 Gatehouse	500
A-22 Incinerator (5-ton trash)	10,000
A-23 Nose type hangars (2)	70,000
A-24 Hangar (Koc'ak type)	72,200
A-25 Shop unit	25,000
A-26 Heads in Hangar Area (2)	2,000
A-27 Ready Ammunition Lockers (3)	1,200
A-28 Wind Tetrahedron	1,200
A-29 Course balls and lights	1,000
A-30 Ready storage shelter (2)	3,000
A-31 Motor assembly and ready motor storage	6,000
A-32 Motor insertion and final assembly	2,000
A-33 Fuse insertion	2,000
A-34 Gasoline storage (5)	100,000
A-35 Fuel Oil Storage	30,000
A-36 Lube oil storage and kerosene storage (2)	10,000
A-37 Water supply and distribution	223,000

THE GRAND EXPERIMENT AT INYOKERN

A-38	Sewer collection and disposal	72,000
A-39	Electrical distribution	90,250
A-40	Field lighting	75,000
A-41	Telephone	14,250
A-42	Fire and crash alarm	6,000
A-43	Drainage	92,000
A-44	General Grading	30,000
A-45	R. R. Spur	112,000
A-46	Roads and Walks	88,000
A-47	Addition to runways and taxiways	325,000
A-48	Plane anchorage and warmup platform	385,000
TOTAL		<u>\$3,169,600</u>

AREA "B" -- PRIMARY TRAINING (AIR) AREA "C" -- LIVE AIR (EXPERIMENTAL) AREA "D" -- INERT AIR (EXPERIMENTAL)

B, C, D - 1	Targets	\$ 4,000
B, C, D - 2	Roads	4,000
B, C, D - 5	Camera Tower and Elec. Control	<u>131,000</u>
TOTAL		<u>\$139,000</u>

AREA "E", EXPERIMENTAL AIR CENTER

	Estimated Project Cost
E- 1 Hangar (Dahlgren)	\$ 300,000
E- 2 Shops	18,000
E- 3 Radio Shop	4,800
E- 4 Storehouse	16,500
E- 5 Photographic Equipment Building	3,500
E- 6 Fire truck and crash alarm building	5,000
E- 7 Control tower and aerolog equipment	25,000
E- 8 Armament assembly station	20,000
E- 9 Subassembly station	1,500
E-10 Ready room	4,000
E-11 H. E. head storage	10,000
E-12 Fuse storage	7,500
E-13 Motor storage	10,000
E-14 Ready storage (2')	4,500
E-15 Bore sight range	4,500
E-16 Garage (4 truck storage) + gas pumps and equipment	6,250
E-17 Inert storage	1,000
E-18 Gasoline storage (200,000 gals.)	100,000
E-19 Lub oil storage (20,000 gals.)	10,000
E-20 Water supply and distribution	117,000
E-21 Sewage collection and disposal	16,000

APPENDIX A

	Estimated Project Cost
E-22 Electrical distribution	107,000
E-23 Field lighting	75,000
E-24 Telephone	8,250
E-25 Fire and crash alarm	3,500
E-26 Drainage	52,000
E-27 General Grading	32,000
E-28 Roads and parking areas	111,000
E-29 Runways and taxiways	1,775,000
E-30 Plane anchorage and warmup platform	552,000
E-31 Dust control (considered to be impracticable, no estimate)	
TOTAL	\$3,400,800

AREA "G", LIVE AND INERT GROUND FIRING

	Estimated Project Cost
G- 1 Launcher platform (2)	\$ 1,200
G- 2 Firing bay (2)	1,500
G- 3 Assembly and loading station (2)	5,000
G- 4 Office and computing building	5,000
G- 5 Shops	5,000
G- 6 Garage	9,000
G- 7 Standard Temperature Building (4)	8,400
G- 8 Refrigerator and oven building (2)	5,400
G- 9 Magazines (4)	12,000
G-10 Radio station	3,000
G-11 Water supply and distribution	93,000
G-12 Sewer collection and disp.	13,000
G-13 Electrical distribution	67,000
G-14 Telephone	6,000
G-15 Drainage	4,000
G-16 General grading	18,000
G-18 Roads and parking areas	1 6,300
G-19 Grading and dust control (considered to be impracticable, no estimate)	
TOTAL	\$372,800

AREA "K", GROUND PLATE

K-1 Launcher platform	\$ 600
K-2 Roads	22,000
	\$22,600

THE GRAND EXPERIMENT AT INYOKERN

AREA "F-H" -- VILLAGE AND HEADQUARTERS AREA

	Estimated Project Cost
FH- 1 Administration Building	\$ 210,000
FH- 2 Aviation Ordnance School	123,200
FH- 3 Electrical and Electronics Lab.	120,000
FH- 4 Precision Instrument, Bombsight, Optical Repair, Photo Lab.	120,000
FH- 5 Physical Test, Heat Treating (Future)	.. .
FH- 6 Ordnance Machine Shop	71,000
FH- 7 Chemical and Explosives Lab.	120,000
FH- 8 Controlled Temp. and Pressure Lab.	60,000
FH- 9 Operations Bldg. (Range Office)	16,500
FH-10a Commanding Officers Quarters	10,000
FH-10b Executive Officers Quarters	9,600
FH-10c Senior Officers Quarters (10)	86,000
FH-10d Jr. Officers Quarters (10 Duplexes) (10)	175,000
FH-11 BOQ (150-Off., 60-OSRD, 100-Engr., 50 Trans.) (9)	360,000
FH-12 Officers Messhall and Recreation	77,000
FH-13 Waves Dormitory (Officers)	24,000
FH-14 Waves Dormitory (Enlisted and CPO's)	85,000
FH-15 Waves Mess hall (Officers and Enlisted)	35,000
FH-16a B-1-B Barracks (175 Student Officers)	60,000
FH-16b B-1-B Barracks (600 Enlisted and CPO's) (3)	180,000
FH-17 Mess Hall	115,000
FH-18 Recreation and Ship Service	25,000
FH-19 Dispensary (Including Boiler Plant)	185,000
FH-20 Public Works Shops	25,000
FH-21 Motor Repair Building	20,000
FH-22 Service Garage	14,000
FH-23 Garage Storage (10 cars and trucks) (2)	11,000
FH-24 Laundry Building	100,000
FH-25 Dry Cleaning Building	15,000
FH-26 Supply Office (Receiving and Shipping)	10,000
FH-27a Storehouses (with platform) (3)	72,000
FH-27b Storehouses (no platforms) (5)	77,000
FH-27c Loading Dock	4,000
FH-28 Cold Storage Building	95,000
FH-29 Fire House	11,000
FH-30 Brig	20,000
FH-31 Incinerator	15,000
FH-32a Gate House	1,500
FH-32b Gate House	400

L. C. HOUSING

FH-33a No Bedrooms (40 Units) (5)	72,000
FH-33b One Bed Room (24 units) (6)	70,000
FH-33c Two Bed Room (24 units) (6)	80,000
FH-33d Three Bed Room (12 units) (6)	57,000
FH-34 Dormitories (100 civilian men) (4)	70,000

APPENDIX A

	Estimated Project Cost
FH-35 Dormitories (100 civilian women) (4)	70,000
FH-36 Commercial Center and Post Office	23,000
FH-37 Community House and Theater	75,000
FH-38 Commissary and Ship Stores	26,000
FH-39 Swimming Pool	175,000
FH-40 School Group (100 Grad and 75 High)	70,000
FH-41 Dispensary Building (Eras ed)	13,000
FH-42 Fuel Oil Storage (2-50,000 gal. fuel storage)	50,000
FH-43 Water Supply and Distribution	517,000
FH-44 Sewage Collection and Distribution	115,000
FH-45 Electrical distribution	212,000
FH-46 Telephone	85,000
FH-47 Fire Alarm	23,000
FH-48 General Grading	33,000
FH-49 Roads and Parking Areas and Walks	269,000
FH-50 Misc. Recreational Facilities	13,000
FH-51 Spur Track	470,000
TOTAL	\$5,346,200

AREA "M", MAGAZINES

	Estimated Project Cost
M-1 Magazines (20)	\$470,000
M-2 Roads	139,000
M-3 Office and Guard House	4,600
M-4 Water Supply	12,000
M-5 Sewage disposal	1,300
M-6 Electrical Distribution	1,200
M-7 Telephone	1,600
	\$629,400

GENERAL ITEMS -- ALL AREAS

Fences and Markers	
Miscellaneous access roads	
Miscellaneous targets, observing towers, bench marks, camera piers, rake stations, revetments, dugouts, barricades.	\$165,000
TOTAL OF ABOVE ITEMS	\$13,245,400
Engineering and Administration, 6%	780,000
Contingent, 20%	2,600,000
GRAND TOTAL	\$16,625,400

Appendix B

California Institute of Technology
Scientist and Supervisory
Personnel (Winter 1944-1945)

PERSONNEL CALIFORNIA INSTITUTE OF TECHNOLOGY

Section I--Design and Development

W. A. Fowler, Supervisor

Projectile Group

T. Lauritsen, Supervisor

C. W. Snyder, Ass't Group Supervisor

C. E. Weinland, Ass't Group Supervisor

C. S. Cox, Research Staff

M. B. Gentry, Research Staff

M. I. LeBow, Research Staff

J. W. McConnell, Research Staff

G. G. Mosteller, Research Staff

R. H. Neil, Research Staff

P. H. Taylor, Research Staff

A. Keast, Research Assistant

H. M. Greene, Research Assistant

L. H. Mahony, Research Assistant

J. N. McClelland, Research Assistant

R. R. Hargrove, Research Assistant

Interdepartmental Order Group

M. L. Green, Supervisor

H. T. Walstaff, Research Staff

Fuze Group

R. B. King, Supervisor

D. E. Brink, Research Staff

H. E. Fracker, Research Staff

J. B. Hatcher, Research Staff

D. L. Kraus, Research Staff

R. E. Martin, Research Staff

J. W. Petty, Research Staff

V. K. Rasmussen, Research Staff

Land and Amphibious Launcher Group

L. A. Richards, Supervisor

J. D. Bascom, Research Staff

P. E. Lloyd, Research Staff

H. Meneghelli, Research Staff

R. E. Sears, Research Staff

E. C. Walker, Research Staff

T. Lofgren, Technical Assistant

R. D. Ridgway, Technical Assistant

Special Launcher Group

A. S. Gould, Supervisor

Ballistics Research Group

F. E. Rosch, Supervisor

C. T. Elvey, Associate Group Supervisor

B. N. Locanthi, Research Staff

D. D. Locanthi, Research Staff

N. U. Mayall, Research Staff

J. N. Schmidt, Research Staff

C. D. Swanson, Research Staff

Theoretical Research Group

L. Davis, Jr., Supervisor

L. Blitzer, Assistant Group Supervisor

J. W. Follin, Research Staff

C. H. Pi, Research Staff

P. W. Stoner, Research Staff

J. G. Waugh, Research Staff

L. I. Epstein, Research Assistant

W. D. Hayes, Research Assistant

Hsue-Shen Tsien, Research Assistant

Drafting Staff

V. F. Ehr Gott, Superintendent

Mechanical Staff

S. A. Macallister, Superintendent

Section II--Aircraft and Ballistics

C. D. Anderson, Supervisor

A. L. Melzian, Assistant Supervisor

C. H. Wilts, Assistant Supervisor

P. E. Edelman, Research Staff

J. L. Kavanau, Research Staff

F. W. Thiele, Research Staff

R. B. Leighton, Research Staff

THE GRAND EXPERIMENT AT INYOKERN

E. C. Briggs, Research Staff
G. M. Safonov, Research Staff
G. Kendall, Design Draftsman
R. C. Poolman, Technical Aide
L. H. Gunnerson, Technical Aide

Fire Control Group

H. W. Babcock, Supervisor
J. I. Bujes, Research Staff
O. D. Frampton, Research Staff
J. L. Fuller, Research Staff
A. M. Shapiro, Research Staff
R. E. White, Research Staff
C. E. Weaver, Research Staff

Section III—Photographic Measurements and Exterior Ballistics

J. S. Bowen, Supervisor
A. H. Andrew, Research Staff
D. P. Barrett, Research Staff
C. C. Baum, Research Staff
F. Crandell, Research Staff
E. Floyd, Research Staff
J. B. Irwin, Research Staff
J. J. Johnson, Research Staff
J. Titus, Research Staff
L. W. Reeder, Research Assistant
G. M. Reger, Research Assistant
L. Ware, Research Assistant

Section IV—Underwater Properties of Projectiles

M. Mason, Section Supervisor
L. B. Slichter, Section Supervisor
B. Hill, Group Supervisor
B. H. Rule, Group Supervisor
N. Haskell, Research Staff
W. P. Funtley, Research Staff
P. M. Hurley, Research Staff
O. C. Johnson, Research Staff
H. G. Taylor, Research Staff
L. Abrams, Research Assistant
A. V. Bunker, Research Assistant
P. Y. Chow, Research Assistant
J. S. Fassero, Research Assistant
R. Fleisher, Research Assistant
B. Gale, Research Assistant
R. Harrington, Research Assistant
R. C. Jackson, Research Assistant
G. A. Spassky, Research Assistant
J. G. Wendel, Research Assistant
M. Zimmerman, Research Assistant
F. Frederick, Mechanical Designer
J. H. Hutti, Mechanical Designer
C. A. Mattson, Mechanical Designer

Section V—Propellants and Interior Ballistics

B. H. Sage, Section Supervisor
D. S. Clark, Section Supervisor
W. N. Lacey, Section Supervisor

Research and Development

P. A. Longwell, Research Supervisor
J. H. Sturdivant, Research Supervisor
R. N. Wimpres, Research Supervisor
C. Allen, Research Staff
R. Bersorn, Research Staff
A. Billmeyer, Research Staff
D. Botkin, Research Staff
T. Bright, Research Staff
W. Colburn, Research Staff
W. Corcoran, Research Staff
W. Eisner, Research Staff
Q. Elliott, Research Staff
H. Ferris, Research Staff
H. Frantz, Research Staff
W. Hansen, Research Staff
A. Hopmans, Research Staff
D. Lemair, Research Staff
R. Olds, Research Staff
H. Vinock, Research Staff
A. Williams, Research Staff
S. Altschuler, Research Assistant
M. Blatt, Research Assistant
J. Brown, Research Assistant
G. Gordon, Research Assistant
L. Green, Research Assistant
K. Korpi, Research Assistant
B. Levedahl, Research Assistant
E. Mead, Research Assistant
E. Miller, Research Assistant
J. Miller, Research Assistant

Technical Control

J. I. Gates, Group Supervisor

Operations

C. L. Horine, Group Supervisor

Experimental Production and Shipping

E. T. Price, Jr., Group Supervisor
L. J. Pollard, Group Supervisor

Inspection

I. Beadle, Group Supervisor

Static Firing

J. H. Sturdivant, Group Supervisor
H. A. Baird, Group Supervisor

Magazine

J. Bancroft, Group Supervisor

Service Operations

Safety

A. D. Ayers, Group Supervisor

Engineering

APPENDIX B

P. Sabin, Group Supervisor
 R. Alcock, Group Supervisor
 F. Eaton, Group Supervisor
 R. Gorschalki, Group Supervisor
 O. Graybeal, Group Supervisor
 E. Olson, Group Supervisor
Installation and Maintenance
 J. Meskell, Group Supervisor
Inventory Records
 A. L. Carleton, Group Supervisor
 D. Taggart, Group Supervisor
Material Control and Stores
 H. Bree, Group Supervisor
Payroll
 H. Meredith, Group Supervisor
Timekeeping
 J. N. Walker, Group Supervisor
Service Group
 A. Ford, Group Supervisor
Accounting
 R. Bretzius, Group Supervisor
Accounts Payable
 L. Ainsworth, Group Supervisor
Procurement
 W. Grundy, Group Supervisor
Shop Procurement
 K. Robinson, Group Supervisor
Personnel
 A. D. Ayers, Group Supervisor
First Aid
 F. M. Bogan, M.D., Group Supervisor
Reports and Editorial
 S. Bradshaw, Group Supervisor
 D. McAllister, Group Supervisor

Section VI—(NOTS Inyokern)
Operations
 R. C. Stone, Group Supervisor
Technical Control
 L. S. Sinclair, Jr., Group Supervisor
Experimental Production and Control
 E. T. Price, Group Supervisor
Inspection
 I. Beadle, Group Supervisor
Safety
 A. D. Ayers, Group Supervisor
 D. L. Dewing, Group Supervisor
Personnel
 A. D. Ayers, Group Supervisor
 D. L. Dewing, Group Supervisor
Payroll and Accounting
 H. T. Jones, Group Supervisor
Material Control and Stores
 H. Bree, Group Supervisor

H. T. Jones, Group Supervisor
Engineering
 E. P. Burke, Group Supervisor
 J. W. Wahler, Group Supervisor
Maintenance
 F. Wood, Group Supervisor

Section VII—Torpedo Launching
 F. C. Lindvall, Section Supervisor
Research
 R. W. Ager, Research
 H. N. Bane, Research
 J. E. Carr, Research
 W. H. Christie, Research
 E. D. Cornelison, Research
 G. Downs, Research
 D. E. Hudson, Research
 A. S. King, Research
 R. Skeeters, Research
 R. B. Moran, Jr., Research
 R. R. Stokes, Research
 F. R. Watson, Research
 J. H. Wayland, Research
 O. C. Wilson, Research
 U. E. Younger, Research
Engineering
 S. Baker, Engineer
 J. Bowen, Engineer
 T. Curtis, Engineer
 A. Ekman, Engineer
 J. French, Engineer
 R. W. Haussler, Engineer
 R. L. Jones, Engineer
 J. H. Jennison, Engineer
 D. A. Kunz, Engineer
 W. Lemm, Engineer
 O. Terrell, Engineer
 W. Saylor, Engineer

Section VIII—Special Ballistics
 W. R. Smythe, Supervisor
 W. B. Dayton, Research Staff
 C. F. Robinson, Research Staff

Section A Project Personnel
 V. E. Wilson, Supervisor
Applicant Department
 D. M. Slaybaugh, Group Supervisor
Employee Clearance and Records Department
 I. J. Miller, Group Supervisor
Medical Department
 F. M. Bogan, M.D., Group Supervisor
 A. E. Martin, M.D., Group Supervisor
Selective Service Department

THE GRAND EXPERIMENT AT INYOKERN

T. W. Nobles, Group Supervisor
Inyokern Department
R. W. Seibert, Group Supervisor

Section B—Developmental Engineering Department

T. Gardner, Supervisor
E. P. Hollywood—Assistant to Section Supv.
L. M. Kiplinger, Assistant to Section Supv.
Production Services Division
Purchasing, Priorities, Material Control—
A. E. Acker, Group Supervisor
D. S. Hammack, Priorities Officer

Contract Service and Transportation
E. F. Tuttle, Group Supervisor
W. K. Tuller, Jr., Asst. to Group Supv.
Contract Service

J. T. Hoffman, Contract Co-ordinator
Transportation, Shipping and Receiving
V. C. Jones, Manager

Production Division
Stanley Guelson, Production Manager
R. T. Stevens, Chief Engineer
J. Trigg, Plant Superintendent

Production Control
P. Clark, Group Supervisor
Salvage and Machine Shop
W. J. McNally, Group Supervisor

Pilot Production
B. Johnson, Group Supervisor
Stenographic
D. E. Harris, Group Supervisor

Section C—Field and Research Operations

W. N. Arnquist, Supervisor
F. W. Pierce, Assistant Supervisor
Range Supervisors
R. H. Cox, Goldstone
D. R. Procter, Muroc
H. L. Prindiville, Camp Pendleton
R. Bogart, Waverly Drive (Pasadena
depot for ranges)

Section D—Project Comptroller

H. Ewart, Supervisor
R. J. Abshire, Assistant Supervisor
Accounts Payable Department
J. D. Pirie, Group Supervisor
Auditing and Accountability Dept.
G. C. Kelsch, Group Supervisor
Cashier and Government Accounting Dept.
C. K. Parks, Group Supervisor
Cost Department
P. Green, Group Supervisor
Payroll Department
R. A. Felnagle, Group Supervisor

Section E—Inyokern Range Operations

E. L. Ellis, Supervisor
G. E. Kron, Assistant Supervisor
P. A. Agnew, Assistant Supervisor
Research Group
G. E. Kron, Group Supervisor
B. O. Davis, Test Co-ordinator
A. H. Ramsay, Staff
L. Stelman, Staff
A. L. Sorem, Safety Co-ordinator
C. A. Wirtanen, Group Supervisor,
External Ballistics
J. E. Thomas, Group Supervisor,
Terminal Ballistics
R. V. Adams, Group Supervisor,
Aircraft Ballistics

Section F—Construction and Maintenance

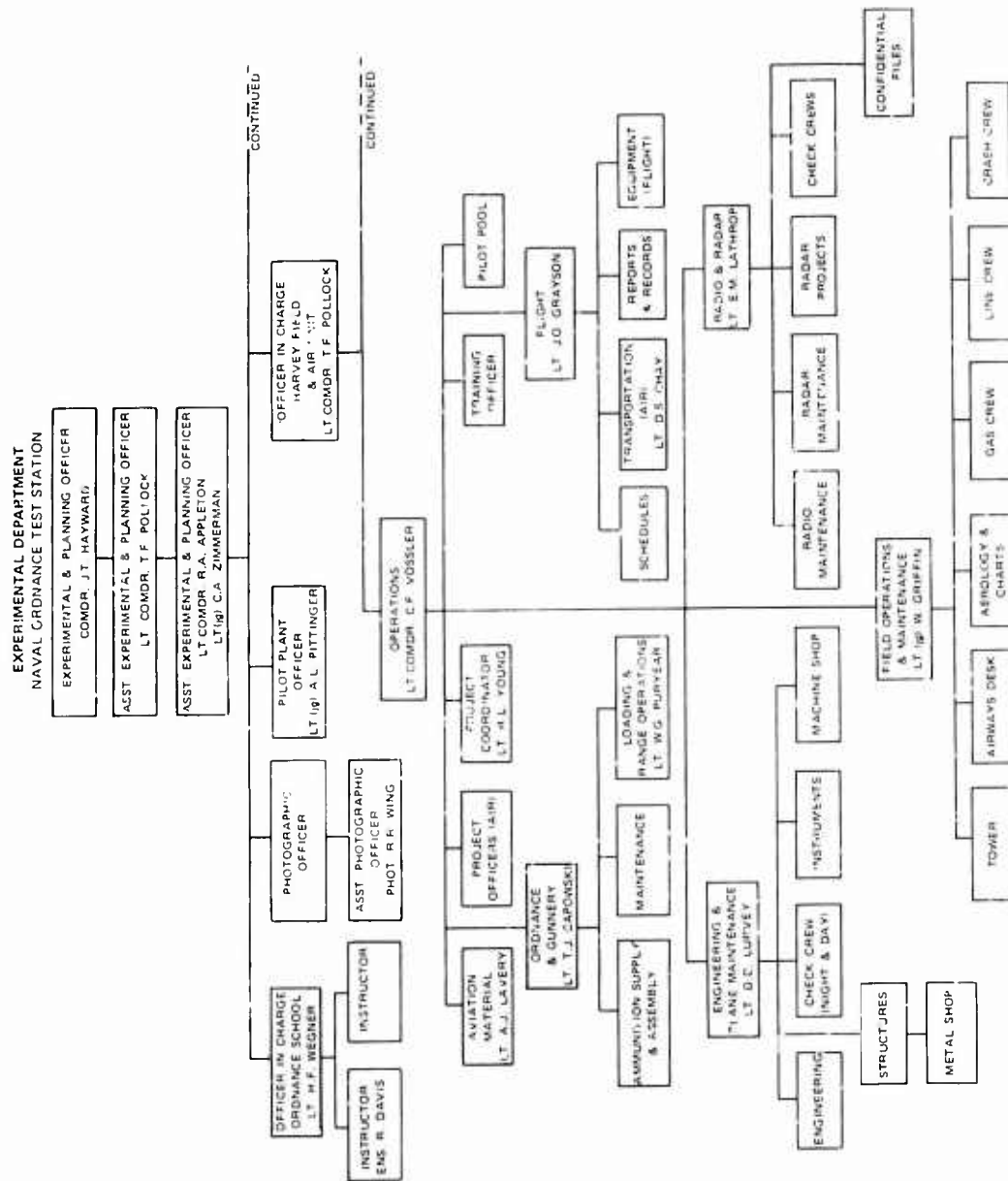
W. Hertenstein, Supervisor

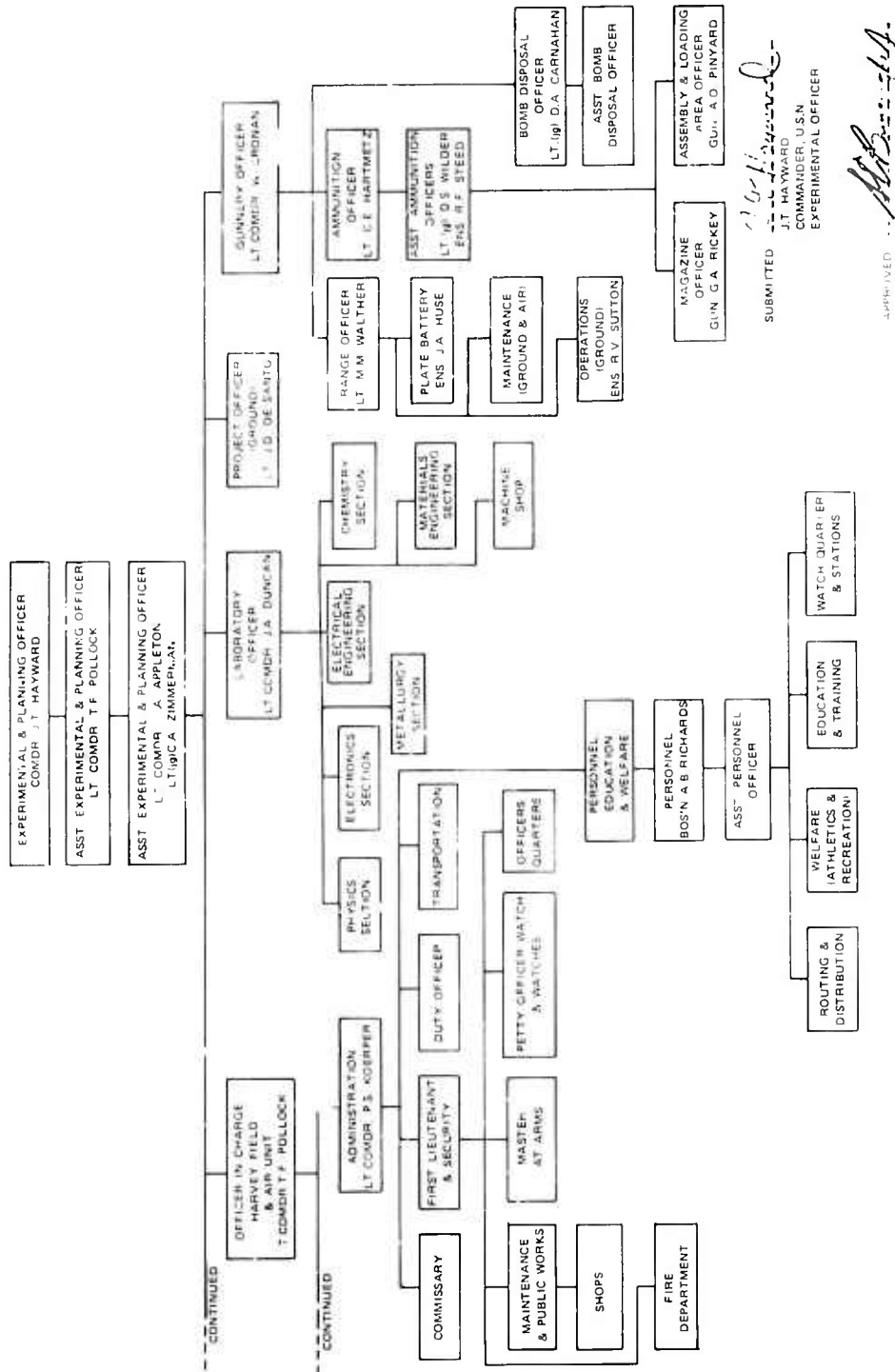
Section R—Editorial Staff

J. Foladare, Supervisor
R. L. Eby, Research Staff
E. L. Wheatfill, Research Staff
R. Winger, Research Staff

Appendix C

Organization of NOTS
Experimental Department
(September 1944)





Appendix D

Summary of NOTS
Construction Progress
(May 31, 1945)

APPENDIX D

TABLE OF WORK PERFORMED UNDER CONTRACT NOy-9088

<u>Project No.</u>	<u>Description</u>	<u>Visible* Completion</u>	<u>Physical* Completion</u>
A-20	Paint and Oil Storage	6-20-44	6-20-44
A-24	Kodiak Type Hangar	10-1-44	10-1-44
A-34	Gasoline Storage (5 tanks)	1-10-45	3-15-45
A-37	Water Supply and Distribution	6-1-45	99%
A-38	Sewage Disposal	2-1-45	99%
A-39	Electrical Distribution	2-15-45	3-15-45
A-42	Telephone	2-15-45	3-15-45
A-43	Drainage	2-15-45	3-15-45
A-44	Grading	2-1-45	5-15-45
A-46	Roads and Walks	11-1-44	3-15-45
A-47	Addition to Runways and Taxiways	9-30-44	2-20-45
A-48	Plane Anchorage and Warmup Platform	7-1-44	7-1-44
A-48A	Magazines for Air Field (2)	12-20-44	3-15-45
Area B	Primary Training (Air)	5-31-44	5-31-44
Area C	Live Air (Experimental)		0%
	Targets		0%
	Roads	9-1-44	9-1-44
	Camera Tower and Electrical Control	12-30-44	99%
E-1	Hangar (Dahlgren Type)	4-25-45	99%
E-2	Shops	4-25-45	99%
E-3	Radio Shop	4-25-45	99%
E-4	Storehouse	1-26-45	99%
E-5	Photographic Equipment Building	4-25-45	99%
E-6	Fire Truck and Crash Alarm	4-25-45	99%
E-7	Control Tower & Aerolog, Equipment	4-25-45	99%
E-8	Armament Assembly Station	4-10-45	99%
E-9	Sub-Assembly Station	3-20-45	4-10-45
E-10	Ready Room	1-15-45	4-10-45
E-11	H.E. Head Storage	2-15-45	5-25-45
E-12	Fuse Storage	2-15-45	3-20-45
E-13	Motor Storage	4-15-45	99%
E-14	Ready Storage (2)	3-15-45	3-20-45
E-15	Base-site Range		0%

THE GRAND EXPERIMENT AT INYOKERN

<u>Project No.</u>	<u>Description</u>	<u>Usable* Completion</u>	<u>Physical* Completion</u>
E-16	Garage, Gas Pumps & Equipment	4-1-45	4-1-45
E-17	Inert Storage	3-7-45	3-20-45
E-18	Gasoline Storage (200,000 Gals.)	4-1-45	4-1-45
E-19	Lub Oil Storage (20,000 Gals.)	3-10-45	3-20-45
E-20	Water Supply and Distribution	4-1-45	99%
E-21	Sewage Collection and Disposal	3-15-45	4-10-45
E-22	Electrical Distribution	4-1-45	90%
E-23	Field Lighting	3-5-45	4-10-45
E-23A	Tetrahedron		0%
E-24	Telephone		35%
E-25	Fire and Crash Alarm	4-25-45	99%
E-26	Drainage	2-1-45	3-5-45
E-27	General Grading	3-5-45	5-1-45
E-28	Roads and Parking Areas	3-5-45	4-10-45
E-29	Runways and Taxiways (1 Runway and Parking)	3-5-45	4-10-45
E-30A	Plane Anchorage & Warmup Platform	3-5-45	4-10-45
E-32	Add. Services for heating plant	5-15-45	95%
G-1	Launcher Platform (2)		0%
G-2	Firing Bay (2)		0%
G-3	Assembly and Loading Station (2)		0%
G-4	Office and Computing Building		0%
G-5	Shop		0%
G-6	Garage		0%
G-7	Standard Temperature Building (4)		0%
G-8	Refrigerator and Oven Building (2)		0%
G-9	Magazines (4)		0%
G-10	Radio Station		0%
G-11	Water Supply and Distribution		25%
G-12	Sewage Collection and Disposal	10%	
G-13	Electrical Distribution		70%
G-14	Telephone		0%
G-15	Drainage		0%
G-16	General Grading		50%
G-18	Roads and Parking Areas	3-1-45	95%
K-1	Launcher Platform		0%
K-2	Roads		2%
FH-1	Administration Building		90%
FH-2	Aviation Ordnance School	5-4-45	98%
FH-4	Precision Inst., Bombsight, Optical Rep. & Photo. Lab.		8%
FH-9	Operations Building (Range Office)		90%
FH-10A	C.O. Quarters	11-17-44	5-15-45
FH-10B	Executive's Quarters	12-9-44	5-15-45
FH-10C	Senior Officers & Scientists Quarters (18)	5-1-45	98%
FH-10D	Jr. Officers & Eng. Quarters (18)	4-25-45	98%
FH-10E	Guest and Transient Accommodations for Scientists, Engineers & Officers	12-9-44	5-15-45

APPENDIX D

<u>Project No.</u>	<u>Description</u>	<u>Usable* Completion</u>	<u>Physical* Completion</u>
FH-11	Bachelor Officers Quarters (150 Officers, 60 SRD - 100 Engs. - 50 Trans.) (3)	1-20-45	5-15-45
FH-11A	Bachelor Officers Quarters (1)	1-20-45	5-15-45
FH-12	Officers Mess and Recreation	10-16-44	3-15-45
FH-14	Waves Dormitory (Enlisted and CPO-220) (2)	2-15-45	3-15-45
FH-16A	B1B Barracks (175 Student Offs.)		0%
FH-16B	B1B Barracks (906 Enlisted) (4)	2-26-45	99%
FH-16C	Marine Barracks	4-15-45	99%
FH-17	Mess Hall	11-15-44	5-15-44
FH-18	Rec. and Ships Services	4-1-45	99%
FH-19	Dispensary	5-1-45	99%
FH-20	Public Works Shops	5-15-45	95%
FH-21	Motor Repair Building	5-15-45	98%
FH-22	Service Garage	5-15-45	90%
FH-23	Garage Storage	5-1-45	98%
FH-24	Laundry Building	10-16-44	3-27-45
FH-25	Dry Cleaning	11-15-44	12-11-44
FH-26	Supply Office	10-20-44	5-15-45
FH-27A	Storehouses (with Platforms) (3)	10-20-44	5-15-45
FH-27B	Storehouses (w) Platforms) (5)	10-20-44	5-15-45
FH-27D	Storehouses - 2 for reclamation	10-20-44	5-15-45
FH-28-Cn	Loading Docks	10-20-44	5-15-45
FH-28	Cold Storage Building & Ice Plant	10-20-44	4-24-45
FH-29	Firehouse	11-5-44	4-24-45
FH-30	Brig	5-14-45	99%
FH-31	Incinerator	2-1-45	2-27-45
FH-32A	Gate House	2-24-45	3-20-45
FH-32B	Gate House		0%
FH-33B	One Bedroom Units 48 (12)	1-15-45	4-15-45
FH-33C	Two Bedroom Units 48 (12)	1-15-45	4-15-45
FH-33D	Three Bedroom Units 24 (12)	1-15-45	4-15-45
FH-53	Two Bedroom Units 200 (100)	5-1-45	98%
FH-54	LCH from Bishop, California (HNA)	11-15-44	12-11-44
FH-34	Dormitories (100 civilian men) (4)	8-28-44	11-21-44
FH-35	Dormitories (100 civilian women) (4)	8-16-44	11-21-44
FH-36	Commercial Center and Post Office	12-20-44	4-24-45
FH-37	Community House and Theatre	5-15-45	99%
FH-38	Commissary and Ships Store	12-25-44	4-17-45
FH-39	Swimming Pool and Recreation (village area)		85%
FH-39A	Swimming Pool and Recreation (Bachelor Officers Quarters Area)		0%
FH-40	School Group (100 grade - 75 high)		0%
FH-42	Fuel Oil Storage (2/50,000 gal.)	3-15-45	95%
FP-43	Water Supply and Distribution	2-15-45	95%
FH-44	Sewage Collection and Disposal	2-15-45	98%
FH-45	Electrical	3-15-45	90%
FH-46	Telephone		40%
FH-47	Fire Alarm		35%
FH-48	General Grading		75%
FH-49	Roads, Parking Areas and Walks	5-15-45	88%

THE GRAND EXPERIMENT AT INYOKERN

<u>Project No.</u>	<u>Description</u>	<u>Usable* Completion</u>	<u>Physical* Completion</u>
FH-50	Miscellaneous Recreation Facilities		0%
FH-51	Spur Track	9-15-45	98%
FH-52	Heating Plant No. 1	3-15-45	95%
M-1	Magazines (20-10 in Inc. No. 1 and 10 in Inc. No. 2)	10-15-44	12-26-44
M-2	Roads	9-1-44	2-20-45
M-3	Office and Guard House	3-5-45	3-13-45
M-4	Water Supply	3-5-45	3-13-45
M-5	Sewage	1-1-45	2-18-45
M-6	Electrical Distribution	3-1-45	3-13-45
M-7	Telephone	3-5-45	3-20-45

GENERAL FACILITIES

Steam Distribution all Area 1		75%
Hi-tens Distribution & Substation		80%
Fencing (A, E, FH, G and M)	10-1-44	99%
Railroad Main Line	5-20-44	5-26-45
Connecting Roads	2-15-45	5-15-45
Miscellaneous Items	5-26-45	5-26-45
Exterior Water Distribution	3-1-45	99%
Miscellaneous Targets, Obs., Towers, BMS, Camera	5-31-45	99%
Piers, Rake Stations, Revetments, Dugouts, Barricades		

CHINA LAKE PILOT PLANT

101	Office Building	2-1-45	5-15-45
102	Gate House and Garage	1-10-45	5-15-45
103	Change House	2-10-45	5-15-45
104	Auto Repair and Grease Rack	2-15-45	5-15-45
105	Machine Shop	2-1-45	5-15-45
106	Shops Lavatory	2-15-45	5-15-45
107	Maintenance Shop	2-1-45	1-15-45
108	Carpenter Shop	2-1-45	5-15-45
109	Warehouse	2-1-45	4-15-45
110	Warehouse with Office	2-1-45	5-15-45
111	Firestation and Marine Barracks	2-1-45	5-15-45
112	Solvent Shed Group	2-1-45	5-15-45
113	Lunch Room		99%
114	Laundry		0%
115	Battery		0%
116	Automatic Telephone Exchange	2-1-45	5-15-45
1	Press Barricade	11-10-44	5-15-45
3	Flaking	11-10-44	5-15-45
4	Annealing	1-10-45	5-15-45
5	Processing	1-10-45	5-15-45
6	Processing	1-10-45	5-15-45
7	Inspection	1-10-45	5-15-45
8	Lunch Room and Toilet		0%

APPENDIX D

<u>Project No.</u>	<u>Description</u>	<u>Usable* Completion</u>	<u>Physical* Completion</u>
9	Inhibiting	4-1-45	5-15-45
10	Curing	4-1-45	5-15-45
11	Lunch and Toilet		0%
17	Grain Boxing	4-1-45	5-15-45
41-44	Rest Houses	1-10-45	99%
12	Grain Grinding	4-15-45	5-15-45
14	Motor Loading	4-15-45	5-15-45
15	Paint & Inspection	4-15-45	5-15-45
16	Motor Parts	4-15-45	5-15-45
18	Motor Boxing	4-15-45	5-15-45
19	Igniter Magazine	4-15-45	5-15-45
51	Press Barricade		95%
52	Sorting and Blending	90%	
53	Control House	97%	
54	Flaking		93%
55	Annealing		97%
56	Processing (Small)		90%
57	Processing (Large)		85%
58	Lunch Room and Toilet		0%
59	Inspection		0%
60	Inhibiting		85%
61	Curing		97%
62	Lunch Room and Toilet		0%
63	Grain Boxing		90%
64	Inhibiting (Small)		80%
69	Combined Motor Loading		85%
81-84	Rest Houses	5-26-45	5-26-45
70	Magazette		99%
201	Grain Rest	3-15-45	4-15-45
202	Motor Rest	3-15-45	5-15-45
203	Igniter Magazine	3-15-45	5-15-45
204	Rest Room and Boiler House	4-15-45	99%
205	Warehouse	3-15-45	5-15-45
206	Experimental Loading		0%
210	Vertical Oven	3-15-45	4-15-45
213	Horizontal Oven	3-15-45	4-15-45
214	Static Firing	3-15-45	5-15-45
214A	Control House	3-15-45	99%
301	3" Press Barricade	0%	0%
302	Grain Storage		0%
303	Future Grain Storage		0%
304	Physical Properties		0%
305	Grain Storage		0%
306	Radiographic		0%
307	Future Storage		0%
308	Experimental Igniter Production		0%
309	Black Powder Storage		0%
310	Igniter Production		0%
311	Finished Igniter Storage		0%
346	Experimental Processing	4-15-45	5-26-45
347	Experimental Processing	4-15-45	5-26-45

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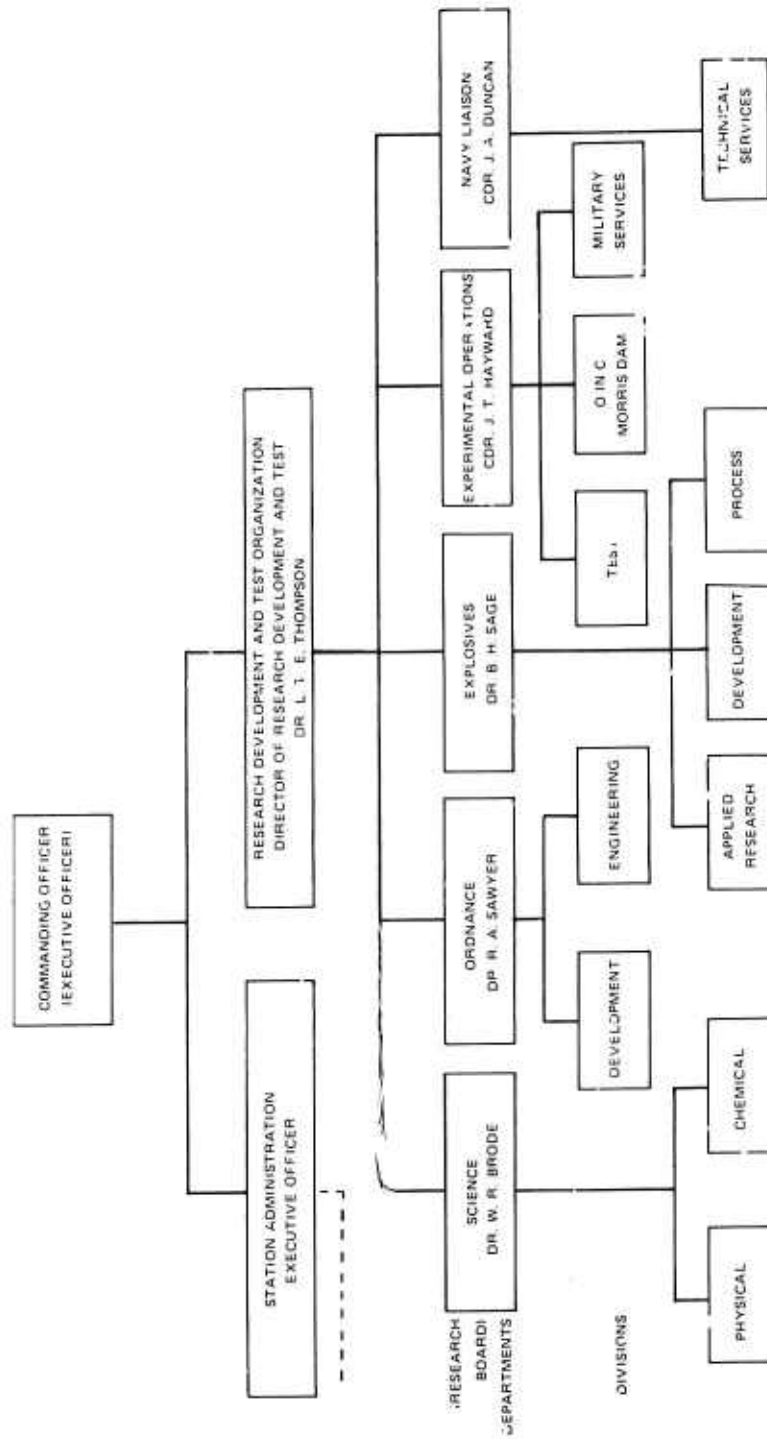
<u>Project No.</u>	<u>Description</u>	<u>Usable* Completion</u>	<u>Physical* Completion</u>
ROADS AND UTILITIES			
1	Sewers	3-1-45	5-15-45
2	Electrical Distribution	11-5-45	5-26-45
3	Water	11-5-44	5-15-45
4	Roads and Drainage	1-1-45	5-15-45
5	Fence	1-1-45	5-15-45
6	Telephone	5-1-45	5-26-45
7	Fire Alarm	5-1-45	5-26-45
8	Loud Speaker-Public Address	5-1-45	5-26-45
1X	Labor Recruiting		100%
3X	200 LCH Bldgs., two bedroom duplex type		80%
4X	Electrical Distribution and Service		80%
5X	Water, Sewer and Heating Distribution		80%
6X	Roads, Sidewalks and Paving		80%
7X	Transfer 5 Buildings LCDF houses from Bishop and reconstruct at Inyokern		0%
8X	High School		0%
9X	Elementary School		0%
10X	Administration Building		0%
11X	Cafeteria for School		0%
12X	Industrial Arts Building		0%
13X	Connecting arcades and walks		0%
14X	Collateral for High School, Elementary Schools, Administration Building, Cafeteria and Industrial Arts Building		0%
15X	Irrigation, grading and landscaping		0%
2X	Installation of extrusion and experimental production equipment in the China Lake Pilot Plant		22%
P-8	Repairs		100%
P-12	40 MM Mounts and other work	5-15-45	5-15-45
P4-A54	Additions to Galley and scullery	9-1-44	9-1-44
P-7-4	Heavy Concrete Wall Targets	8-21-44	9-7-44
P-917C	Inert Storehouse	4-1-45	5-1-45
P9-18C	Inert Storehouse	4-15-45	5-1-45
P9-63C	Inert Storehouse	5-31-45	5-31-45
P9-69C	Inert Storehouse		95%
16X	Area "CT"	4-15-45	5-15-45
17X	Area "ER"	3-3-45	4-15-45
18X	Temporary Housing Units for 200 Families		90%

* Where any project was not completed under this contract the percentage completed as of the termination date of 31 May 1945 is given.

Appendix E

First Postwar Organization for
Research, Development, and Test
(December 1945)

RESEARCH DEVELOPMENT AND TEST ORGANIZATION



APPROVED - *J. H. Baker*
 4 DECEMBER 1945

Appendix F

NOTS Principles of Operation
as Approved by the
Bureau of Ordnance
(October 21, 1946)

PRINCIPLES OF OPERATION

PREAMBLE

The mission of the Naval Ordnance Test Station was defined in a letter by the Secretary of the Navy, Opl3C-je, Serial 232213, dated 8 November 1943, as that of "a station having for its primary function the research, development and testing of weapons, and having additional function of furnishing primary training in the use of such weapons." The Bureau of Ordnance in a letter to the Commanding Officer, NOTS (A) NP36 dated 30 March 1944, placed special emphasis on the development of rocket weapons, guided missiles, and aviation ordnance, as well as the training operations necessary for proper use of new weapons.

It is the intention of this station that its facilities will be so organized and operated as to insure the successful conduct of its research, development, and test program with effectiveness fully equivalent to that attained during the war by the OSRD groups working in the corresponding fields.

In order to accomplish the stated mission, it is necessary to attract and hold a technical staff of the highest caliber. To attract and hold such individuals, it is necessary to provide a working environment and encouragement of outside contacts comparable to those found in major academic and industrial research and development centers.

CONSTITUTION OF AUTHORITIES

1. COMMANDING OFFICER

The Commanding Officer is the head of the Naval Ordnance Test Station, subject in the performance of his duties to the Navy Regulations and existing competent directives. In view of (1) the primary function of this station as a research and development establishment, (2) the high percentage of civilian population, and (3) the isolated location requiring residence on the station of practically all

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employees, the administrative problems are complex and unusual. In order to assist the Commanding Officer, the following boards and positions are established to which the Commanding Officer will delegate the requisite responsibility and commensurate authority. Action under such authority is subject to review by the Commanding Officer.

2. ADMINISTRATIVE BOARD

The Administrative Board shall consist of the Commanding Officer as chairman, the Technical Director as Vice-Chairman, the Research Board, and such other persons as may be designated by the Commanding Officer or by the Administrative Board with the approval of the Commanding Officer and the Technical Director. The Administrative Board shall propose administrative policy and procedures for the operation of the station.

3. TECHNICAL DIRECTOR

The Technical Director of the Research and Development Organization shall be delegated control of the research, development, and training activities, including methods of conducting research. The Technical Director will propose distribution of personnel and facilities assigned to the station and conduct projects in accordance with the priority set up by directives from the Bureau of Ordnance.

4. RESEARCH BOARD

The Research Board shall consist of the Technical Director as chairman, the Experimental Officer, and the department heads of the research and development departments or such other members as the Technical Director may designate. The Research Board reviews technical programs and advises the Technical Director with regard to their establishment and conduct.

/s/ JAMES B. SYKES
Captain, U.S.N., Commanding

Approved:

/s/ G. F. HUSSEY, JR.
Chief of the Bureau of Ordnance
Date 21 October 1946

SN/231

Sources

A GENERAL NOTE ON METHODS AND SOURCES

The research for Volume 1 of this series provided a sound bedrock for this follow-on work, which covers a significant five-year segment of the history of the Naval Weapons Center.

But beyond the hard currency of documented information, the value of the Volume 1 legacy was remarkable in other ways: for example, in the establishment of research trails and in the personal contacts with individuals and organizations whose interest in our second volume continued undiminished, as did their unstinting support of our endeavors. Most notable among these is the Naval History Division and its Operational Archives Branch. Their extensive collections of documents and unpublished narrative histories enabled us to reconcile our Center's local history with the larger ones of the U.S. Navy and the Bureau of Ordnance, and thus enlarge its dimensions.

From the Federal Records Center, Mechanicsburg, Pennsylvania, we obtained the long-term loan of early log books of the Naval Ordnance Test Station. These were most helpful in verifying events and their dates and times with great precision, as well as stimulating a special awareness of the routine day-to-day life at the young desert Station.

From the Federal Records Center, Bell, California, we recovered the entire set of Commander, NOTS (ComNOTS) records of the Naval Weapons Center (circa 1943-47).

As our history developed from World War II into the postwar period, we found that the informational resources at NWC were adequate to meet our needs for historical research. The Center's early

correspondence folders are extensive, and a primary source for much that appears in this volume. In particular, we were aided by the ready availability of key documents on file in the Records Management Group of the Center's Office of Finance and Management.

In the preparation of this second volume of NWC's history, *people* have continued to represent a most prized informational resource. Because of this recognition, we have continued our comprehensive oral history program. Most of the principals had already been interviewed during the preparation of Volume 1, and the scope of the follow-on interviews was largely designed to include their role in the postwar period. Sometimes interviewees were selected as part of the overall historical research thrust in a particular area: certain interviews with former NOTS Pasadena employees and early Research Department scientists fall into this category.

Many of the published works that subscribed to Volume 1 continued to serve us for this successor volume; notably, *Rockets, Guns and Targets*, by John E. Burchard. However, the list of published works was considerably enlarged to include such reference works as *Organizing Scientific Research for War*, by Irvin Stewart, and *U.S. Navy Bureau of Ordnance in World War II*, by Buford Rowland and William B. Boyd. In addition, much valuable information on naval aviation was derived from NAVAIR Report 00-80P-1, *United States Naval Aviation, 1910-1970*.

The unpublished manuscript has played a vital part in the compilation of this history. Usually written close to or at the time of the events covered, the unpublished narrative is generally a factual treasure house. This was found to be true regarding most such works used in Volume 2. Of special significance have been the vastly comprehensive *Narrative of the Bureau of Ordnance*, and D. S. Fahrney's *History of Pilotless Aircraft and Guided Missiles*; both of these useful documents are held by Operational Archives, Naval History Division.

Sources are given in this section under the headings Interviews and Bibliography.

INTERVIEWS

An extensive series of interviews was held by the authors to provide information for both the published history of the Naval

SOURCES

Weapons Center and for a planned biography of Rear Admiral W. S. Parsons. The dual purpose of the interview program accounts for both subjects frequently being treated in the same interview.

In most cases the interviews were tape-recorded and copies of the transcript were sent to the interviewee for corrections and additions. Transcripts of most of the interviews are available for scholarly research in the Technical Information Department, Naval Weapons Center, China Lake, California, and in the Operational Archives, Naval History Division, Washington, D.C.

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In the Beginning . . . Indian Wells Valley Masonic History, by Mort Bergren. (NWC 2313, 1209.)

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